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CHANGES IN THE CHITINASE ACTIVITY DURING POSTEMBRYONIC DEVELOPMENT OF THE BLOWFLY *CALLIPHORA VICINA* R. D.

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(*Received* 10 *May* 1989)

Free and bound chitinase activity showed cyclical variations during postembryonic development of the blowfly *Calliphora vicina*. The activity increased during first two moults followed by a decline. During change of feeding to wandering behaviour of third instar larva, a small increase followed by a decrease was noticed. During pupariation, the activity rose again to attain a peak in early pupa for free and mid pupa for bound enzyme. This time difference is perhaps due to time needed for deproteinization of the cuticle and binding of enzyme to the chitin. Further, the enzyme activity was maintained at moderate level till adult emergence. The results are discussed in terms of physiological significance and possible ecdysteroid titres during development of cyclorrhaphous Diptera.

(*Key words:* chitinase, chitinolytic, moulting fluid, postembryonic development, blowfly, *Calliphora vicina*)

INTRODUCTION

Insect development is periodic in nature. During moulting old cuticle is detached from the epidermis, new cuticle is synthesized and old one is removed. Before shedding, almost 90% of old cuticle is degraded, absorbed and reutilized (BADE & WYATT, 1962). This is brought about with the help of enzymes present in the exuvial or moulting fluid secreted in the space between old and new cuticle. PLOTNIKOV (1904) and TOWER (1906) first suggested digestion and solubilization as the actual function of moulting fluid. WIGGLESWORTH (1933) demonstrated protease activity and suggested the existence of a chitinase in the moulting fluid. HAMAMURA & KANEHARA (1940) provided first experimental proof of chitinolytic activity before ecdysis in the silkworm, *Bombyx mori*. Chitinases and their role in digestion of old cuticle have been studied in detail in some Lepidoptera only. Chitin degradation in insects has been reviewed by SPINDLER (1983) and KRAMER *et al.* (1985).

The development of cyclorrhaphous Diptera is different from other Holometabola in respect that larval cuticle itself is transformed into sclerotized puparium. In the present study, chitinase activity in the whole body homogenate and pellet (free and bound enzyme respectively) was determined in *Calliphora vicina*.

MATERIALS AND METHODS

A laboratory colony of the blowfly, *Calliphora vicina* R. D. (*C. erythrocephala* MEIGEN) was maintained on sugar, yeast and water. The egg laying was done on fresh meat. The larvae remian feeding on meat for about 5 days during which they moult twice to reach the third instar. Then the larvae come out of the meat and wander for about 2 days before they pupariate. The larvae and pupae from 1 day of hatching to the day of adult emergence were taken for chitinase estimation.

Pooled (1–3 day larvae) and single (from 4th day larvae onward) individuals

were washed and homogenized in ice cold distilled water in a mortar and pestle. The homogenate was centrifuged in cold and the supernatant was used for free and water washed pellet for bound enzyme assay.

The chitinase activity was measured by using colloidal chitin (prepared according to MONAGHAN *et al.* (1973) as substrate and the end product, N-acctyl-D–glucosamine was measured using 3–5 dinitrosalicylic acid reagent of NOELTING & BERNEFLED (1948).

The reaction mixture consisted of 0.5 ml of colloidal chitin (0.25% in H_2O), 2.0 ml of acetate buffer (0.05 M, pH 4.5)– saline (0.4 M). The mixture was equilibriated for 10 min at 37°C and then 0.5 ml of enzyme solution was added. Incubation was done in a water bath at 37°C for 3 hours. For bound enzyme activity, 2.0 ml of buffered saline and 1.0 ml of H_2O were added in the washed pellet and incubation was done at 37°C for 20 hours. The reaction was terminated by adding 0.5 ml of 4 N NaOH, the mixture was centrifuged at 3000 rpm for 15 min and 0.5 ml of DNSA reagent was added in the supernatant. The mixture was heated at 100°C for 10 min, cooled in ice bath and read at room temperature at 500 nm in a spectrophotometer.

The colour (optical density, OD) readings were converted into the amount of glucosamine released with the help of a standard graph prepared by using N-acetyl-D-glucosamine as standard.

RESULTS AND DISCUSSION

In most of the studies on insect chitinases, the whole body or tissue homogenate supernatant was employed without bothering about the enzyme that might have lost bound with pellet (chitin). BADE (1974, 1975) reported significant chitinase activity bound in the old cuticle of *Manduca sexta.* BADE & STINSON (1978) suggested that induction of moulting fluid chitinase takes place sequentially in several steps: penetration of the active moulting fluid into the endocuticle, removal of proteins (unmasking of chitin) by proteases, attachment of chitinase to the deproteinized cuticle, degradation of chitin, reabsorption of end products and removal of enzymes.

Preliminary observations have shown that just homogenization of the developmental stages of *Calliphora vicina* was not enough to extract the chitinase enzyme. When the pellet of homogenate was incubated in buffer, release of NAGA indicative of bound chitinase, was noticed. Therefore, we decided to estimate free and bound chitinase activity respectively in supernatant and pellet.

The chitinolytic activity was expressed in three ways: (1) in terms of per mg body weight; (2) in terms of per individual and (3) in terms of per mg protein content in the supernatant (specific activity).

The pattern of chitinolytic activity in the pellet which might be assumed to enzyme associated with integument, is expressed in Fig. 1. The chitinase activity per mg body weight was already at a moderately higher level on first day, increased enormously to reach a maximum peak at second day. The first and second day respectively represent the approximate period of first and second moultings. On the third day the activity declined steeply. It increased further from fourth to the end of fifth day (onset of wandering), decreased little during wandering and increased again during pupariation. The activity showed a second biggest peak in mid-pupal stage. In late pupal development, the activity was maintained at fairly moderate level till just before adult emergence.

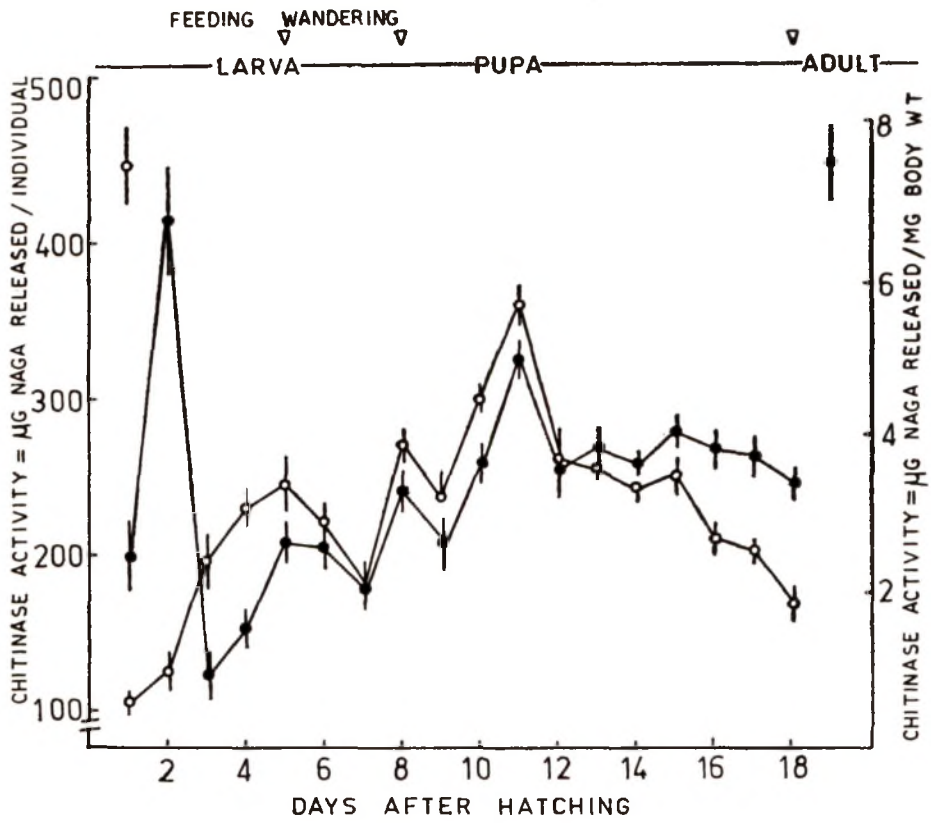

Fig. 1. Bound (pellet) chitinase activity pattern during postembryonic development of *Calliphora vicina*.

During early larval period (1 to 3 days), the body weight and the total amount of chitin present is very less, therefore, less chitin is to be hydrolyzed. Thus as expected very low chitinase activity per individual was observed. The enzyme activity from fourth day onwards showed almost a similar pattern as that of enzyme activity per mg body weight. However, during late pupal development, the enzyme activity is significantly lower than the activity per mg body weight. This difference might be due to the presence of less chitin to be hydrolysed from sclerotized puparium at this moment.

The chitinolytic activity in the whole body supernatant is expressed in Fig. 2. The chitinase activity per mg body weight began as that of the pellet : high in 1-day larva, reaching a peak on 2nd day, then steeping down at its lowest level, increasing again to reach a second peak shortly after the start of wandering (5th day), coming down during wandering and increasing during pupariation. But unlike in pellet, here the peak was obtained on 9th day (1-day pupa). In pupal development, the activity came down a little, maintained as such, reduced sharply and showed a small rise before adult emergence.

The chitinase activity per individual showed very low levels during early larval and late pupal development as in pellet. At other periods it is more or less similar to the enzyme activity per mg body weight.

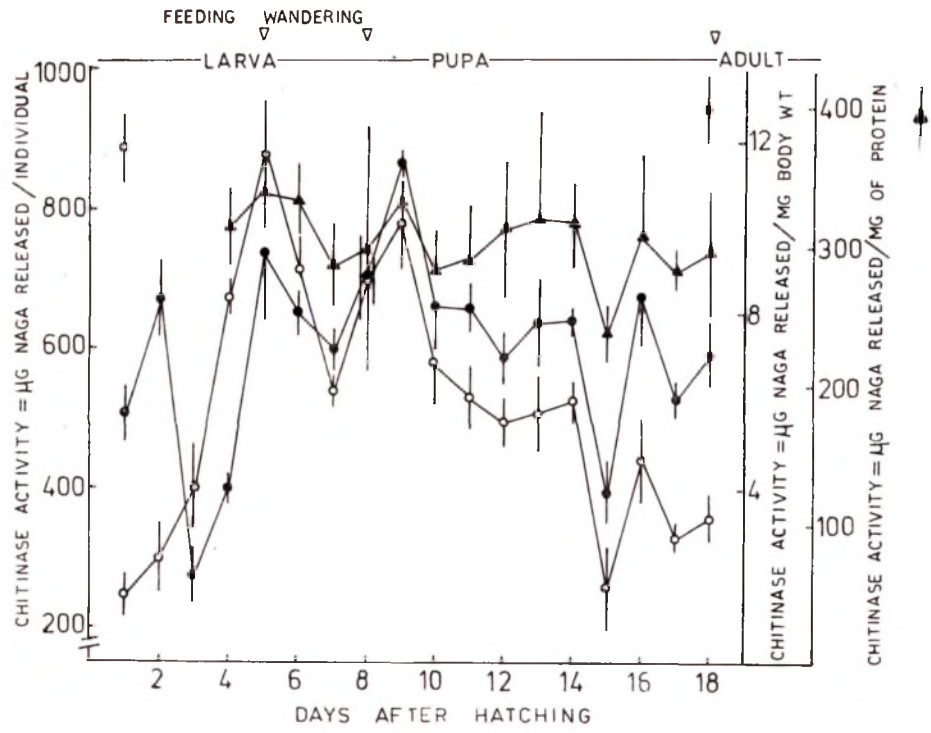

Fig. 2. Developmental pattern of free (supernatant) chitinase activity of *Calliphora vicina*.

The specific chitinase activity could not be determined in early larval periods. From feeding 3rd instar larva onwards, the specific chitinase activity followed a pattern which is more or less statistically insignificant. The total protein contents vary greatly during the life of Holometabola in connection with varying physiological events. If the present results of specific chitinase activity are compared with those of WINICUR & MITCHELL (1974) in *Drosophila*, there seems to be a similarity of pattern from late larva to adult emergence of two insects, that enzyme activity showed almost no change. Thus the whole body protein seems not to be good factor to relate with chitinase activity which has a specific target i.e., integument. Due to similar reasons VAN PELT VERKUIL (1979) and AGRAWAL *et al.* (1989) found that the total protein content was unsuitable as a reference for acid phosphatase activity in the fat body of *Calliphora erythrocephala* and whole body of *Sarcophaga lineaticolis* respectively.

Both free and bound chitinase activity showed a correlation with moulting and metamorphosis, only when expressed in terms of per mg body weight. Therefore, chitinase activity per mg body weight is considered in following discussion.

A comparison of the present results of free and bound chitinase activity with developmental events and the possible ecdysteroid titres in cyclorrhaphous Diptera (as described by ZDAREK, 1981) is shown in Table 1. It is clear that free and pellet bound chitinase activity is high when the ecdysterioid concentration should also be high for regulation of moulting, feeding to wandering behaviour and metamorphosis. During pupal life, the free enzyme activity

showed a peak in 1 day pupa, while in pellet the activity showed a peak 2 days later. This time difference is perhaps due to deproteinization of the cuticle followed by the binding of chitinase to the chitin (BADE & STINSON, 1978). The moulting hormone seems to trigger chitinase (s) and its binding to the susceptible chitin.

The present observation is in accordance with the findings of CHEN *et al.* (1982) in *Stomoxys calcitrans* and of SINGH & VARDANIS (1984) in *Musca domestica* that the peak of chitinase is in the mid pupa when the high concentration of ecdysteroid should also be present. However, WINICUR & MITCHELL (1974) in *Drosophila* could not observe cyclical changes in the chitinase activity during last instar larval and pupal development.

In most Holometabola the larva moults into pupa and maximum chitinase activity is also during this period. A direct induction of chitinase activity by 20-hydroxy ecdysone could be shown in last instar larvae of *Bombyx mori* (KIMURA, 1973) and *Manduca sexta* (FUKAMIZO & KRAMER, 1987). But in cyclorrhaphous Diptera the third instar larval cuticle is not shed but transformed into a sclerotized puparium, therefore, we observed relatively smaller increase in chitinase activity during larval-puparial transformation in *Calliphora vicina*.

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TABLE 1. Relationship of bound and free enzyme activity with the developmental events and 20-hydroxyecdysone titres.

Developmental stages and events	Ecydysteroid levels	Bound chitinase activity	Free chitinase activity
1–day larva (1st moult)	Increases	High	High
2–day larva (2nd moult)	Increases more than on 1–day	Largest peak	1st peak which drops soon
3–day larva	Low	Lowest	Lowest
4-day larva	Increasing	Increasing	Increasing
5-day larva (feeding to wandering switch-over)	Small peak	Small peak	IInd peak which reduces soon
Pupariation	Sharp and short peak	Increasing	Increasing
Early pupa	Small decrease	Maintained	Largest peak
Mid pupa	Maximum in life cycle	IInd largest	Lower
Late pupa	—	Maintaind at a significant high level.	Declines and increases a little.

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HISTOCHEMICAL CHARACTERIZATION OF THE SECRETORY GRANULES IN THE TESTIS OF *GRYLLODES SIGILLATUS* (WALKER) (ORTHOPTERA : GRYLLIDAE)

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(*Received* 30 *July* 1989)

The testis of *Gryllodes sigillatus* contains spheroidal translucent basophilic secretory granules, ranging in size from 3 to 15 μm in diameter. They are numerous and occur in the testicular follicles as intratubular droplets. Histochemical characterization of these granules reveals that they contain proteins, acid mucopolysaccharides and glycogen. They appear to be lacking in lipids, DNA and RNA. They are abundant among spermatids and sperm, suggesting some role in sperm maturation and maintenance.

(*Key Words:* *Gryllodes sigillatus*, secretory granules, testicular follicles, sperm maintenance)

INTRODUCTION

Besides sperm production, the testis of many invertebrates has secretory function (BLUM, 1970; ADIYODI & ADIYODI, 1975; GILLOTT, 1988). Among insects there is only suggestive evidence for a glandular role of the mesodermally derived testicular cells (GILLOTT, 1988). The Principal function of the testicular secretory cells is to supply nutrients to the differentiating spermatozoa, while in some species the nutritive cells themselves or their secretory products accompany the spermatozoa as they are transported to the seminal vesicles, to serve a trophic function (GILLOTT, 1988). Studies on the types of secretory cells and their products have been reported only in a few species of insects (ANDERSON, 1950; VAN WYK, 1952; CANTACUZENE, 1968; LUSIS *et al.*, 1970). Histochemical studies on this score are also limited to a few species (CANTACUZENE, 1968; LUSIS *et al.*, 1970). The present investigation is an attempt to study the histochemical characteristics of the testicular secretory granules in *Gryllodes sigillatus* (Walker).

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MATERIALS AND METHODS

Adult males of *G. sigillatus* were collected from the store houses. The testes were dissected out in insect Ringer solution and fixed in Carnoy's fluid for 24 h (SUBRAMANIAM, 1984). Paraffin sections (8 μm thickness) were stained with Delafield's haematoxylin and eosin. For histochemical characterization of the secretory granules, tests for proteins, carbohydrates, lipids, and nucleic acids, as shown in Table 1, were carried out following the methods as in PEARSE (1968) and CHAYEN *et al.* (1973).

RESULTS

The testes of *G. sigillatus* are paired whitish oval bodies, lying one on either side of the gut in the abdominal cavity. Each testis consists of testicular follicles, ranging between 65 and 75, enclosed in a common peritoneal sheath. The follicles

contain male germ cells at different stages of differentiaton. Besides, there are numerous spheroidal translucent granules as intrafollicular droplets (Fig. 1). The granules range in size from 3 to 15 μm in diameter and are strongly basophilic (Fig. 2). They are abundant and interspersed among the spermatids and spermatozoa. Histochemical studies reveal that the secretory granules are composed of proteins, acid mucopolysaccharides and glycogen (Table 1). The protein moiety consists of basic and acidic amino acids as revealed by the strong positivity to aqueous bromophenol blue and mercuric bromophenol blue respectively. Mild positivity to Millon's test shows the presence of tyrosine in traces. The metachromatic nature is evidenced by the postitive reaction to toluidine blue. The secretory granules, however, are deficient in tryptophan and sulphur containing amino acids as reflected in the negative reaction to DMAB- nitrite and performic acid-Schiff tests respectively. PAS reaction with appropriate controls and the alcianophilic nature at low molar concentration (0.2M $MgCl_2$) reveal that the granules are non-sulphated acid mucopolysaccharides. Moderate positivity to Best's carmine shows the presence of glycogen. The secretory granules contain no lipids, DNA and RNA as evidenced by the negative reaction to Sudan IV, Feulgen and methyl-green pyronin tests respectively.

DISCUSSION

Morphological and histological characteristics of the testicular secretory granules have been reported only in a few insects such as acridids (CANTACUZENE, 1968) and roaches (LUSIS *et al.*, 1970). In these insects, the secretory granules are spheroidal and basophilic and are of varying sizes. The spheroidal translucent basophilic granules of varying sizes occurring in the testis of *G. sigillatus* are also similar to those of acridids and roaches. Histological evidences in *G. sigillatus* suggest that the granules are secreted possibly by the basophilic cuboidal epithelial cells of the testicular follicles. The secretory granules in the testis of *G. sigillatus* fixed in Carnoy's fluid and 10% neutral buffered formalin appear distinct, although LUSIS *et al.* (1970) have reported that the Secretory granules have not been observed in Carnoy fixed tissues.

Todate, only a few histochemical studies have been carried out to elucidate the nature of substances produced by the testicular

Fig. 1. A testicular follicle showing the secretory granules (SG) interspersed among the differentiating sperm (DS). Fig. 2. Magnified view of the basophilic secretory granules (SG).

TABLE 1. Histochemical characterization of the secretory granules in the testis of *Gryllodes sigillatus*.

TEST	FOR	RESULT
Mercuric bromophenol blue (Hg BPB)	General and acidic proteins	+ + +
Methylation + HgBPB	Acidic group blocked	—
Aqueous bromophenol blue (ABPB)	Basic proteins	+ + +
Deamination + ABPB	Basic group (–NH2) blocked	—
Ninhydrin–Schiff	Free Amino (–NH2) group	—
Million's	Tyrosyl group	+
Iodination + Millon's	Tyrosyl group blocked	—
DMAB – nitrite	Tryptophanyl group	—
Ferric-ferricyanide	Sulphydryl group	—
Performic acid-Schiff	Disulphide group	—
Toluidine blue (TB)	Acid mucosubstances	+ +
Methylation – TB	Acidic group blocked	—
Schiff alone	Free aldehydes	—
Periodic acid-Schiff (PAS)	1, 2, *Vic* glycol groups and glycogen	+ + +
Diastase + PAS	Digestion of glycogen	+ +
Acetylation + PAS	1, 2 glycol group blocked	—
Deacetylation + PAS	1, 2 glycol group released	—
Delipidation + PAS	Lipid extraction	+ + +
Best's carmine (BC)	Glycogen	+ +
Diastase + BC	Digestion of glycogen	—
Alcian blue at critical electrolyte concentration	Acid mucosubstances	
0.2 M $MgCl_2$	Weakly sulphated	+ +
0.6 M $MgCl_2$	Strongly sulphated	—
0.8 M $MgCl_2$	Only strongly sulphated	—
1.0 M $MgCl_2$	,,	
Bracco-Curti	Sulphate group	—
Sudan IV	Lipids	—
Feulgen test	DNA	—
Methylgreen – pyronin	RNA	—

+ Weakly positive; + + moderately positive; + + + strongly positive; — negative.

nutritive cells (GILLOTT, 1988). These studies reveal that the secretory materials contain muco-proteins (CANTACUZENE, 1968) mucoproeins and lipids (LUSIS *et al.*, 1970). The histochemical characterization of the secretory granules in the testis of *G. sigillatus* reveals that they contain proteins, acid-mucopolysaccharides and glycogen. The negative reactions observed in the Feulgen test and methyl green-pyronin test reveal the absence of DNA and RNA in the secretory granules and confirm that they are but the secretory products of testicular cells. Further, the secretory products of *G. sigillatus* differ from those of other insects in containing glycogen. The glycogen as well as acid mucopolysaccharides in the secretory granules of *G. sigillatus* possibly serve as readily available carbohydrate reserve, supplying nutrients to the spermatozoa. That the secretory granules are distributed among the spermatids and spermatozoa suggests a role in sperm maturation and maintenance. GILLOTT (1988) has stated that the products of secretory cells of insect gonads most often appear to play a role in nourishment of developing and mature gametes. Further, the energy released during the conversion of glycogen is possibly utilized by the differentiating germ cells as well as mature sperm in *G. sigillatus* as suggested for the role of glycogen in the accessory reproductive gland secretion in *Plebeiogryllus guttiventris* (RENGANATHAN, 1970).

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CHROMOSOME STUDIES OF ORIENTAL ANOPHELINES: A COMPARISON OF THE SALIVARY GLAND CHROMOSOMES OF *ANOPHELES LEUCOSPHYRUS* AND *A. JEYPORIENSIS*

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(*Received* 9 *May* 1989)

'Standard' chromosome maps of *Anopheles leucosphyrus* and *A. jeyporiensis*, both belonging to the subgenus *Cellia* have been proposed. A gross comparison of these maps with those of congeneric species, *A. dirus*, *A. tessellatus*, *A. maculatus* and *A. aconitus* has been attempted. In terms of relative homologies in banding patterns, *A. leucosphyrus* appears closer to *A. dirus*, *A. tessellatus* and *A. maculatus* while, *A. jeyporiensis* appears closer to *A. dirus*, *A. tessellatus* and *A. aconitus*. The need for more definitive information on both genetical and cytological studies of a large number of anopheline species of the subgenus *Cellia* is stressed.

(*Key words:* *Anopheles leucosphyrus*, *Anopheles jeyporiensis*, chromosomes, bands)

INTRODUCTION

Interest in cytogenetic studies of mosquitoes has grown considerably during the recent years and importance of the cytogenetic approach in the analysis of closely related species of anopheline has been demonstrated by several workers. Karyotypes and polytene chromosome maps are now available for several anopheline species. However, there is paucity in cytogenetic knowledge of the tropical fauna, especially of our Oriental region. The genetics and cytogenetics of mosquitoes have been reviewed by different workers (KITZMILLER, 1953, 1963, 1967, 1976; KITZMILLER et al., 1967; CHOWDIAH et al., 1971; PAL et al., 1981). Some important papers on the polytene chromsome maps of anopheline species studied by different workers refer to *A. fluviatilis* (CHOWDAIAH & SEETHARAM, 1975; SHARMA & CHAUDHRY, 1976), *A. kompi* (KITZMILLER et al., 1976), *A. jamesi* (SHARMA, 1976), *A. Philippinensis* (SHARMA, 1977), *A. culicifacies* (SAIFUDDIN et al., 1978; JAYAPRAKASH & CHOWDAIAH, 1980), *A. ramsayi* (CHAUDHRY, 1979), *A. dirus* (BAIMAI et al., 1980), *A. aconitus* (SHARMA et al., 1980), *A. annularis* (VARMA & SHARMA 1981), *A. sinensis* (XU et al., 1982), *A. varuna* (PASAHAN, 1981), *A. aitkenii* and *A. gigas* (JAYAPRAKASH & CHOWDAIAH, 1982) and *A. lindesayi* (SHARMA et al., 1982).

The 'standard' chromosome maps of *Anopheles leucosphyrus* and *A. jeyporiensis*, both belonging to the subgenus *Cellia* have been prepared by the author and presented in this paper. These maps have been compared with chromosome maps of some other Oriental species of the same subgenus.

MATERIALS AND METHODS

Anopheles leucosphyrus Donitz used in the present study is a vector of simian malaria (WATTAL, 1975) and belongs to the group Neomyzomyia of the subgenus *Cellia*. It has a wide distribution in the Oriental region (CHRISTOPHERS, 1933). Mitotic chromosomes of *A. leucosphyrus* were prepared from the brain tissue of larvae collected exclusively from water collections at the base of arecanut trees of the Pomological garden near Burliar, Nilgiri hills, South India.

Anopheles jeyporiensis James, the type form used in the present study is a 'suspect-vector' (WATTAL, 1957) and belongs to the group Myzomyia of the subgenus *Cellia* with a restricted distribution to India only (CHRISTOPHERS, 1933). Mitotic chromosomes of *A. jeyporiensis* were prepared from the brain tissue of larvae collected from slow running streams connected with rice cultivation near Napoklu village of Kodagu District, Karnataka State.

Polytene chromosome slides were prepared from the salivary glands of fourth instar larva following the standard method for anophelines (FRENCH et al., 1962). Measurements were taken from selected photographs of polytene chromosome complements and the details of the banding pattern were studied by direct observation of the chromosomes at a magnification of 1000 × under oil immersion using a Zeiss Amplival Photomicroscope.

RESULTS

Description of the chromosomes:

The diploid chromosome number of six characterizes each of the species studied as is typical of the anophelines (Figs. 1 and 2). Interestingly, the sex chromosomes in the female of *A. leucosphyrus* are acrocentric (Fig. 1) and submetacentric in *A. jeyporiensis* (Fig. 2).

The salivary chromosome complement of both *A. leucosphyrus* and *A. jeyporiensis* consists of five polytene elements representing three pairs of chromosomes a short acrocentric *X* chromosome in the former and a short submetacentric *X* in the latter with indistinct centromeric region and two pairs of longer metacentric autosomes with arms of distinguishable legth (Figs. 3 and 4). Autosomal arms in each case have been identified and designated as 2*R*, 2*L*, 3*R* and 3*L*. The *X* chromosome which is the shortest in the complement contains zones 1 to 6; while autosomes 2*R*, zones 7 to 19; 2*L*, zones 20 to 28; 2*R*, zones 29 to 37 and 3*L*, zones 38 to 46 (Figs. 5 and 6). However, the lettering of the subdivisions within each zone is arbitrary.

Anopheles leucosphyrus (Figs. 3 and 5):

X chromosome: This is the shortest chromosome in the complement. The free end is slightly spherical and marked by two pairs of dark bands in region 1 A and a series of dark discontinous bands and a dark band on either side at the constriction in 1B. A pair of heavy bands in 2B followed by a series of characteristic dark bands in region 3 and 4A forms a good landmark. Region 5 as a whole with a series of characteristic dark bands mostly wavy-forms an excellent landmark for the centromeric end.

Chromosome 2, right arm: This is the longest autosomal arm in the complement. Region 7B and the region 8 as a whole with a series of more evenly spaced dark bands serve as an excellent landmark for the distal end of the chromosome. Region 10C followed by region 11 as a whole with a series of recognizable dark bands as seen in the map is diagnostic. Region 12 consisting of three more or less identical puffs is conspicuous. Region 13B with three heavy dark bands is prominently seen. A series of dark bands present in 16B through 17 and 18 as a whole forms a good landmark for the proximal end of the chromosome. Four dark bands in 19A, two in 19B and five in 19C are equally diagnostic.

Chromosome 2, left arm: This is the shortest autosomal arm. This arm can easily be recognized by a conical-shaped free end and a series of prominently seen heavy dark bands constitute the zone 28. Series of characteristic dark bands present in the region 26 as a whole forms a good landmark for the distal end of the chromosome.

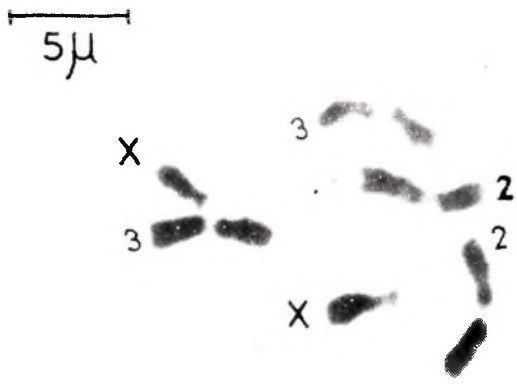

Fig. 1. Mitotic chromosomes (Female fourth instar larval brain) of *Anopheles leucosphyrus*.

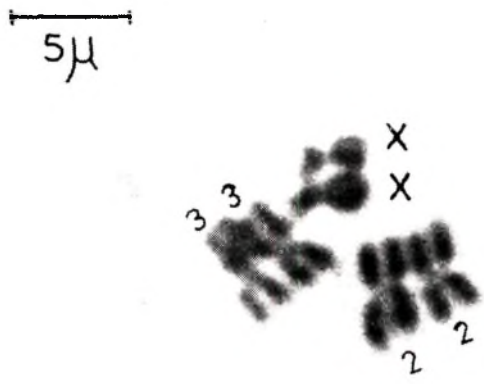

Fig. 2. Mitotic chromosomes (Female fourth instar larval brain) of *Anopheles jeyporiensis*.

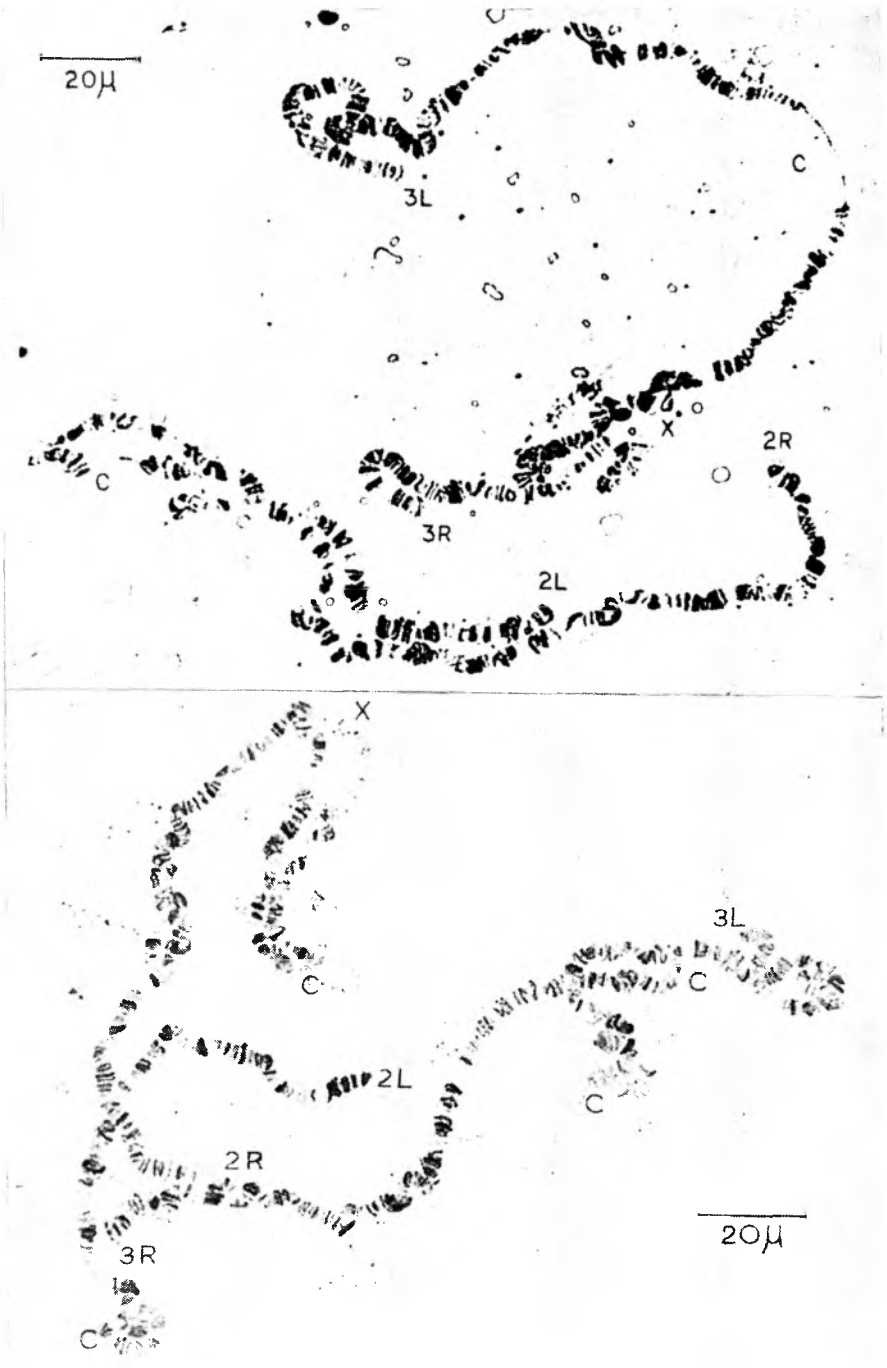

Fig. 3. (below) Entire salivary gland chrosmosome complement of *Anopheles leucosphyrus*. C, centromere; X, X–chromosome; 2R and 2L, right and left arms of chromosome. 2; 3R and 3L, right and left arms of chromosome 3. Fig. 4. (above) Entire salivary gland chromosome complement of *Anopheles jeyporiensis* (lettering as for Fig. 3).

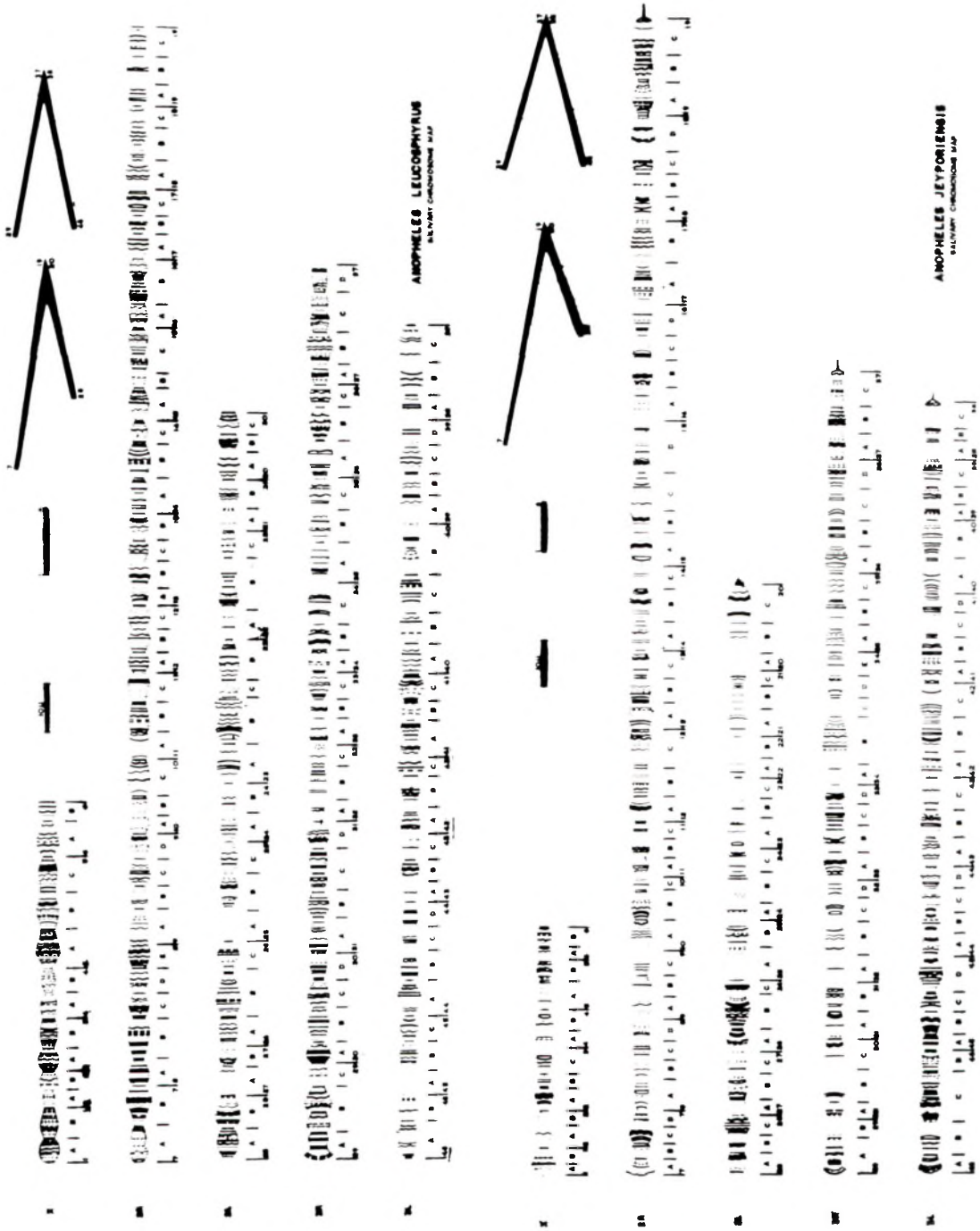

Fig. 5. (left) Salivary gland chromosome map of *Anopheles leucosphyrus*.
Fig. 6. (right) Salivary gland chromosome map of *Anopheles jeyporiensis*.

Except for the light puff in 23 C, the region 23 as a whole constitutes a diagnostic area for the middle portion of the chromosome which is characterized by a series of dark bands. A series of both medium stained and darkly stained bands present in 21B and 20 as a whole together serve to identify the centromeric end.

Chromosome 3, *right arm:* The free fan-shaped fringed end in 29A consists of two heavy discontinuous bands followed by three pairs of characteristic dark bands. The puffs that follow in 29B present a series of prominent dark heavy bands. A series of dark bands in region 30 and 31 forms an excellent landmark for the distal end of this arm. Region 34 as a whole with a series of dark bands forms a good recognition area for this portion of the arm. Region 36 followed by region 37 as a whole with a characteristic series of dark bands mostly wavy serve to identify the proximal area of the arm.

Chromosome 3, *left arm:* The conical shaped free end in the region 46A with a pair of dark bands followed by a pair of medium stained and a pair of dark bands is prominently seen. Regions 45B through 45C and 44 as a whole form the first landmark for this arm. Region 43B containing a group of dark bands is consistently seen. Regions 42 and 41 together with a series of characteristic dark bands offer a good landmark for the middle portion of the arm. Dark bands present in the regions 40B through 40C and 40D is equally diagnostic. Regions 39 and 38 together with a series of dark bands characterize the centromeric end of the chromosome.

Anopheles jeyporiensis (Figs. 4 and 6):

X chromosome: The *X* chromosome is recognized by its short length. The spindle shaped free end is marked by three dark bands in the region 1B. Region 3 as a whole with a series of dark bands serve as the best landmark for this portion of the chromosome. The puff in the region 4B is seen with three dark bands. A group of characteristic dark bands in 5B followed by three dark bands in 6A and a series of five dark bands in 6B together constitute a distinct landmark for the centromeric end.

Chromosome 2, *right arm:* This is the longest autosomal arm in the complement. The fan-shaped free end in 7A is readily recognized by a wavy dark band. A group of four heavily stained bands in the region 7C forms the first landmark for the distal end of the arm. A series of four dark bands placed at the constriction in between puffs in 10A and 10B stand prominently. Two pairs of thick heavy bands in the region 12A and a series of dark and medium stained bands in 12B together constitute a good landmark for this portion of the chromosomal arm. Region 14B followed by region 15 A and 15B with a series of dark bands which are mostly wavy form an excellent recognition area for the middle portion. The region covering 17, 18 and 19 with several series of recognizable dark bands serves to identify the proximal region.

Chromosome 2, *left arm:* This is the shortest autosomal arm. It can easily be recognized by its dome-shaped free end and a conspicuous series of dark bands representing the region 28 as a whole. A group of closely placed dark heavy bands present in the region 26 as a whole serves as an excellent landmark for the distal end of the arm. Region 25B is seen with four loosely spaced dark bands. Region 21 as a whole is diagnostic for a series of characteristic thin dark bands. Two pairs of heavy curved dark bands in 20C serve to identify the proximal end of the arm.

Chromosome 3, *right arm:* The free end in 29A is fan-shaped and is identified by a pair of dark bands in the beginning followed by a dark doublet present at the constriction. A group of 3-1-2 dark bands in the zones 30A and 30B is characteristic. Regions 30C and 31 containing a series of dark bands together serve as a good landmark for the distal end of the arm. A characteristic series of dark bands in the region 33 form an excellent landmark for the middle portion of the chromosomal arm. A series of dark bands which is present in the zones 36 and 37 as a whole serves to identify the proximal portion of the arm.

Chromosome 3, *left arm:* The free end in the region 46 A is recognized by the presence of two sets of dark bands of three each. A series of dark bands characterizing the regions 46C, 46D and 45 serves as a good landmark for the distal end of the arm. Dark bands present in the regions 44A and 44B are equally diagnostic. Regions 42B and 42C with a group of closely placed bands of varying intensity are diagnostic for this portion of the chromosome. Region 41 as a whole is characterized by a series of evenly spaced dark bands. Regions 40 and 39 with a series of characteristic dark bands together form and excellent landmark for the proximal portion of the arm. Region 38B is marked by two dark doublets which are constantly seen in all the preparations. A series of lightly stained bands followed by two dark wavy bands in 38C marks the centromeric end.

DISCUSSION

Comparative studies of the polytene chromosomes of mosquito species offer an excellent opportunity to understand their evolutionary and phylogenetic relationship. These studies have shown that closely related species and even sibling species may sometimes be distinguished on the basis of the banding patterns (COLUZZI & SABATINI, 1967; KITZMILLER et al., 1967). Morphologically similar species are expected to have more similar banding patterns than species with little morphological similarity (KITZ MILLER et al., 1967).

A band-to-band comparison between the chromosome map of *A. leucosphyrus* with those of some other closely related species of the subgenus *Cellia*, including *A. Maculatus* (NARANG et al., 1973), *A. tessllatus* (NARANG et al., 1974) and *A. dirus* (BAIMAI et al., 1980) has been attempted. It is seen that *A. leucospyrus* shares more extensive homologies in the banding pattern with *A. dirus* and *A. tessellatus*, both belonging to the group Neomyzomyia than with that of *A. maculatus*, belonging to the group Neocellia. These species could represent different steps in the line of *A. leucosphyrus*, *A. dirus*, *A. tessellatus* and *A. maculatus*.

Similarly a gross comparison of the chromosome map of *A. jeyporiensis* with those of some other closely related anopheline species of the subgenus *Cellia* has been attempted. These species include *A. tesselatus* (NARANG et al., 1974), *A. dirus* (BAIMAI et al., 1980) and *A. aconitus* (SHARMA et al., 1980). *A. jeyporiensis*, belonging to the group Myzomyia shares significant similarities in the banding pattern with *A. dirus* and *A. tessellatus*, both belonging to the group Neomyzomyia and *A. aconitus* belonging to the group Myzomyia. Summarizing the chromosomal picture *A. jeyporiensis*, *A. dirus*. *A. tessellatus* and *A. aconitus* represent steps differentiating these species in the same line of their relationship.

This clearly indicates the subgeneric character of the chromosomal banding pattern which apparently has undergone a definite sequence of evolutionary changes within the subgenus *Cellia*.

However, any attempt to explain the evolutionary relationships based on the chromosomal comparison alone, that too of a few species would be arbitrary. Hence, more definitive information on intraspecific and interspecific crosses and cytogenetic studies of a large number of species is very much warranted.

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MATING BEHAVIOUR OF *LYSIPHLEBIA MIRZAI* SHUJA-UDDIN (HYMENOPTERA: APHIDIIDAE), A PARASITOID OF *RHOPALOSIPHUM MAIDIS* (FITCH) (HEMIPTERA: APHIDIDAE)

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Lysiphlebia mirzai **is an aphidiid parasitoid of corn aphid** *Rhopalosiphum maidis*. **The courtship and copulatory behaviour involves the exchange of several sexual stimuli between the sexes. Copulation starts 7-50 min after the emergence. Mating behaviour comprises three phases: (1) courtship behaviour (2) copulatory behaviour and (3) post-copulatory behaviour. The actual copulation lasts for 14.0±2.58 sec. The copulation period is not affected by the parasitoid's starvation. Multiple copulation occurs with the male but never happens with the female. A fully fed male of** *L. mirzai* **mates with upto 22 females while starved male mates only with upto 16 females in his life. The non-receptive female either moves away as soon as a male approaches her or discourages the male by characteristic antennal movement and bending down of the abdomen. Olfatcion of female's pheromone secretion plays a significant role in exciting and luring the male. Older mates do not actively court or copulate.**

(*Key words:* *Lysiphlebia mirzai*, *Rhopalosiphum maidis*, courtship, mating behaviour)

INTRODUCTION

Mating behaviour (courtship and copulation, VAN DEN ASSEM, 1986), is obviously an aspect of sexual reproduction and involves the exchange of several sexual stimuli between the sexes which act as an ethological barrier between closely related sympatric species (VAN DEN ASSEM & POVEL, 1973; EVANS & MATTHEWS, 1976). STARY (1970) considered it as a factor that determines the working efficiency of the parasitoid. Few genuinely ethological studies of mating behaviour in parasitic wasps have been published so far (BARRASS, 1960; MATTHEWS 1975; GORDH & DEBACH, 1978; VIGGIANI & BATTAGLIA, 1983). Many descriptions of mating procedures among aphidiids (Hymenoptera) are scattered in the literature but most are fragmentary and sketchy (SCHLINGER & HALL, 1960, 1961; ASKARI & ALISHAH, 1979). Recently, this behaviour was studied in some detail for only three species of aphidiid wasps from India, *viz.*, *Diaeretiella rapae* (M'Intosh) (DHIMAN *et al.*, 1987); *Kashmiria aphidis* Stary and Bhagat (DAS & CHAKRABARTI, 1986); and *Trioxys indicus* Subba Rao and Sharma (SINGH & SINHA, 1982).

Lysiphlebia mirzai Shuja-Uddin (Hymenoptera: Aphidiidae) is an indigenous parasitoid of the corn aphid *Rhopalosiphum maidis* (Fitch) (Hemiptera: Aphididae). Locally it was found as a dominant aphidicidal bioagent against *R. maidis* on the pearl-millet, *Pennisetum typhoides* (a graminaceous crop cultivated for cereal and fodder). In the present paper mating behaviour of *L. mirzai* is described.

MATERIALS AND METHODS

The aphid *R. maidis* was reared on young seedlings of the host plant *P. typhoides* grown in clay pots at 20 ± 1°C, 70–80%

RH, L:D : 10:14 hour. The parasitoid *L. mirzai* was reared on some of the newly established aphid colonies on the host plant. Mummies of *L. mirzai*, taken from the laboratory stock, along with the pieces of food plant leaf were kept individually in glass tubes (5×1 cm). A piece of moistened filter paper was kept inside the tube to provide proper humidity for the developing parasitoid. When the parasitoid egressed out from the mummies, time of emergence was recorded. For the study of mating behavior, newly emerged and fed (with 50% honey solution) virgin female and male were released into a glass tube (15×1 cm). The behaviour was observed visually. The mating behaviour of starved individuals was also observed. The following observations were recorded: a. pre-excitation period; b. pre-encounter period; c. pre-copulation period; d. events of the mating behaviour and e. successive mating by male in his life.

RESULTS AND DISCUSSION

The mating behaviour of the parasitoid *L. mirzai* may be devided into three steps, *viz.*, (1) courtship (*i. e.*, pre-copulatory) (2) copulatory and (3) post - copulatory behaviour.

Courtship behaviour: Just after the emergence, both the sexes of the parasitoids groom *i.e.*, dry and clean different body parts, *viz.*, antennae, mouth-parts, wings, abdomen and genitalia with the help of pretarsi of all the legs. Then, feed depending on the availability of food. The precopulation period in *L. mirzai* varies from 7 to 50 min (32.33 ± 16.45 minutes). However, many workers observed that copulation among aphidiids occurs almost immediately or soon after emergence (SCHLINGER & HALL, 1960, 1961; SINGH & SINHA, 1982; DAS & CHAKRABARTI, 1986; DHIMAN *et al.*, 1987). However, VEVAI (1942) and SEKHAR (1957) reported that copulation does not occur in the first hour just after emergence. STARY (1970) opined that it is species specific.

When the sexes (one pair) were kept together in the glass tube, after the end of the preparatory phase (Fig. 1) (*i. e.*, grooming phase) the male gets excited by the presence of female (Fig. 2) and starts vibrating its wings within few seconds, even before contact with the female. It implies that chemical (pheromonal) stimuli are involved in this process as in other aphidiid wasps (READ *et al.*, 1970; ASKARI & ALISHAH, 1979; SINGH & SINHA, 1982). Other cues, e.g., tactile and visual, play a role in becoming oriented in a proper way.

During excitement, the male moves his antennae up and down with a higer frequency. At this time, the female as in other aphidiid parasitoids plays passive role (Fig. 3) (SCHLINGER & HALL, 1960, 1961; STARY, 1970; SINGH & SINHA, 1982; DAS & CHAKRABARTI, 1986; DHIMAN *et al.*, 1987). As the time rolls, the male becomes more and more excited, frequently moves antennae, vibrates the wings very rapidly and trails the female (Fig. 4) similar to other aphidiid wasps. Virgin females show readiness to copulate during the first display by a conspecific male. With the onset of sexual receptivity there is a change in the female's posture, which is probably a necessary consequence of the readiness to copulate: a female has to raise her abdomen to expose the genital orifice to make copulation possible (VAN DEN ASSEM, 1986). Female *L. mirzai* with the onset of sexual receptivity sits quietly, folds her legs slightly and spreads her wings horizontally over the abdomen. A courting male directly perceives this change which blocks further courtship and makes him switch to copulatory behaviour.

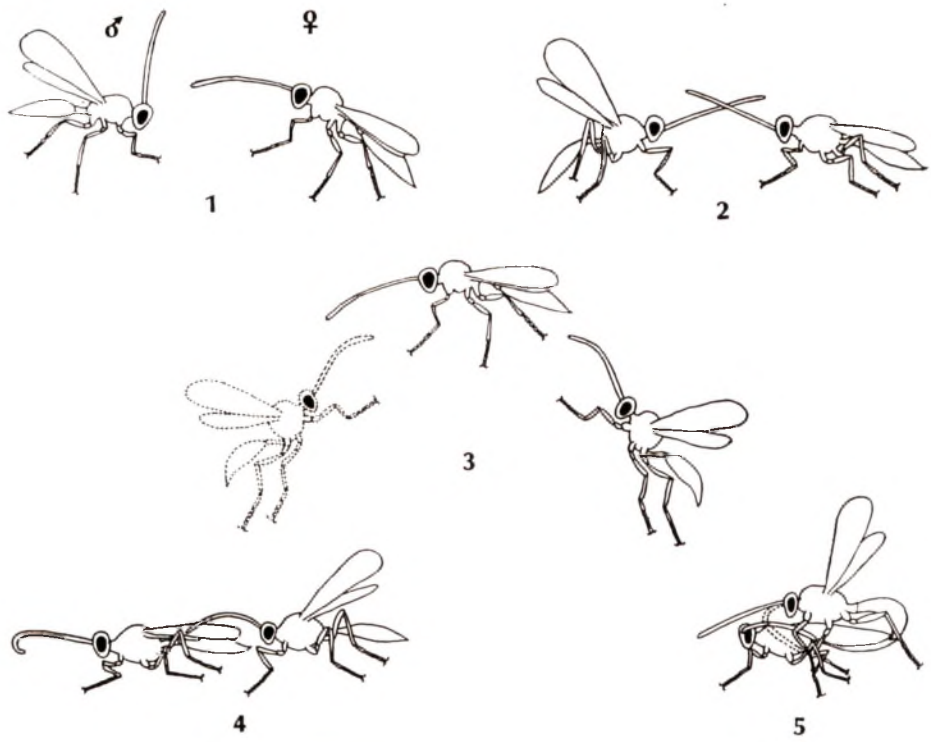

Fig. 1–5: Mating behavior of *Lysiphlebia mirzai* Shuja-Uddin
(Fig. 1–4: Phase of preparation; Fig. 5: Act of copulation).

Copulation behaviour: On the receipt of this signal (changed posture of females) the male obviously sures about the receptivity of the females. He secures his position the back of the female. He taps the head of the female with antennae. Frequently he brushes the antennae of female with his own. He grasps the female firmly with his legs in such a manner that his fore- and mid-legs hold her mid- and hind-legs respectively. The fore-legs of the female and hind-legs of the male are free. Simultaneously, the male places his hind-legs against the posterior part of the female's abdomen for a footing on the substratum. Now the male curves his abdomen downward and forwards so that his genitalia come into contact with that of female (Fig. 5). During copulation male vibrates his wings at high frequency and continues to brush female's antennae with his own. Then, he inserts the aedeagus into the genital orifice of the female and inseminates her. The copulation lasts for 14.0 ± 2.58 seconds. The copulation period remains unaffected by the starvation of the mates.

Post - copulatory behaviour: After the completion of successful copulation, the male dismounts from female and goes away from her. Immediately after insemination, the male shows post-copulatory behaviour. Within a few seconds the male exhibits the same courtship pattern for the repetition of post-copulatory courtship. Usually this time the female again signals her receptivity (at the very start of display), but as a rule, the male's internal condition soon changes. He becomes unresponsive to such stimulus. Similarly female is no longer in a reactive mood following signalling and copulation.

Second signal for mating by the female soon after the first act due to inadequate sperm transfer has already been refuted long back by BARRASS (1964). Now this behaviour is regarded as a requisition to switch off the receptive conditions (VAN DEN ASSEM & VISSER, 1976). After some time, if the same male tries to mount her back again, she totally refuses. She either moves away as soon as male approaches her or discourages the male by characteristic antennal movement, head jerking (side-wise in 'no' position) and bending down the abdomen. Thus the female *L. mirzai* copulates once in her life-time, though the male can successfully copulate with upto 22 females. Polygamy in males is common among aphidiids (SEKHAR, 1957; SCHILINGER & HALL, 1960, 1961; SINGH & SINHA, 1982; DAS & CHAKRABARTI, 1986; DHIMAN *et al.*, 1987).

Effect of starvation of the parasitoid on the successive copulatory behaviour: For the completion of different phases of mating, fed parasitoids take insignificant time than starved parasitoids (Table 1). A fully fed male of *L. mirzai* (fed parasitoid) may mate with upto 22 females while a starved male mates only upto 16 females in his life. VEVAI (1942), SEKHAR (1957), SINGH & SINHA (1982), DAS & CHAKRABARTI (1986) and DHIMAN *et al.* (1987) reported 13–18, 19, 5, 7 and 4–6 times respectively as the multiple successive copulation of male for different aphidiid parasitoids. We observed that the number of matings of a male wasp is significantly correlated with food and fully supports the findings of DAS & CHAKRABARTI (1986). Older mates (male and/or female) do not actively court or mate, possibly due to their physical disability or less production of sex pheromone (VAN DEN ASSEM, 1986). In addition to these factors, body size of the male also influence his mating potential (VAN DEN ASSEM, 1986).

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TABLE 1. Quantitative measurements of sexual receptivity in *Lysiphlebia mirzai*.

Different phases of mating	Fed parasitoids (mean ± SD) n = 10	Starved parasitoids (mean ± SD) n = 10
Pre- copulation period (min)	32.33 ± 16.45	34.0 ± 14.71 NS
Time taken by male for excitement (sec)	39.3 ± 13.72	61.2 ± 27.93 NS
Time taken by male in making 1st contact with female (sec)	55.3 ± 26.12	108.0 ± 47.15 NS
Courtship period (sec)	19.3 ± 6.01	24.6 ± 6.93 NS
Copulation period (sec)	14.0 ± 2.58	16.7 ± 2.79 NS
Successive copulation by male in whole life	19.2 ± 1.92	12.6 ± 2.40*

* Mean differences are significant, $P<0.05$ (t-test);
NS – not significant

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FOUR NEW SPECIES OF GENUS *EPILACHNA* CHEVROLAT (EPILACHNINAE: COCCINELLIDAE: COLEOPTERA) FROM INDIA

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Four new species of the genus *Epilachna* Chevrolat have been described from India.

(*Key words*: *Epilachna*, phytophagous, tegmen, spiho)

INTRODUCTION

Epilachninae (Coccinellidae : Coleoptera) includes medium or small sized insects which are phytophagous and many are acting as pests. Workers like Mulsant (1850), Crotch (1974), Weise (1895, 1900), Korschefsky (1931), Dieke (1947), Kapur (1950, 1958, 1959, 1965, 1971, 1972, 1979) have contributed a lot towards the taxonomy of Coccinellidae of Asia. The present paper describing four new species of genus *Epilachna* Chevrolat is a step towards that. It is a part of an extensive and intensive survey made under a DST project on Coccinellidae.

Epilachna shilliensis sp. nov.

♂, ♀—Body shortly oval and slightly convex; pubescence greyish white. Head reddish brown with dark brown apices of mandibles. Pronotum dull reddish brown with subtriangular black spot, situated in the middle near front margin. Scutellum reddish brown. Elytra dull, reddish brown with six black spots arranged as 2, 2, 1, 1. Scutellar spot situated a little behind scutellum on suture and continuous with its counterpart on other elytron to form a rounded spot; humeral spot rounded, situated on humeral callus and touching humeral margin; discal spot subrounded, situated at the level of external margin of scutellar spot and slightly anterior to the transverse median line; lateral median spot rounded, hardly touching external margin and situated slightly posterior to the level of discal spot; post-median spot situated on suture and continuous with its counterpart on other elytron to form rounded spot as scutellar spot; subapical spot suboval transversely placed and slightly closer to external margin than suture (Fig. 1). Underside black with reddish brown prosternum, legs, elytral epipleurae and lateral border of abdominal sternites.

Head almost 4/7 of pronotal width; punctation fine, moderately close and sparse on interocular space; pubescence thin and depressed; antenna almost equal to width of head, 11-segmented, slender, 1st segment largest and swollen, 3rd segment slightly less than twice of 2nd, segments 4 to 8 subequal in size, last three segments form serrate club, segment–11 largest in club and pointed apically (Fig. 4); mandible with one tridentate apical and one mesal tooth, dentules missing (Fig. 3). Pronotum 7/11 of body width, widely emarginate anteriorly, anterior corners narrowly rounded, whereas, posterior corners broadly rounded; lateral margins broadly rounded; punctation fine and close; pubescence thin and subdepressed. Scutellum equilaterally triangular with fine and few punctures; pubescence thin. Elytra with

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humeral angles broadly rounded and prominent humeral callus, lateral margins gently arcuate, apex rounded; punctation mixed: coarse punctures well-defined and sparse, whereas fine punctures minute and ill defined.

Underside with elytral epipleurae not foveate. Prosternum with moderately wide processes and noncarinated. Mesosternum with anterior margin slightly curved. Metasternum with fine punctation. Tarsal claw bifid without basal tooth. Abdominal lines terminal, complete, broadly rounded and reaches near the posterior margin of 1st-abdominal sternite (Fig. 5); abdominal sternites with punctation fine and close. Apical margin of last visible abdominal sternite rounded in female and slightly emarginate in male.

Male genitalia: Tegmen poorly developed. Median lobe well-developed, slightly curved and swollen near apex which becomes swollen afterward and ends into a pointed tip. Lateral lobes slender and smaller than median lobe, slightly bent in middle, opposite to median lobe, apical 1/3 clothed with moderately long setate. Tegminal strut thin and slender (Fig. 2). Sipho bends strongly near base and slightly in opposite direction near 2/3 of its length, slightly constricted near tip; siphonal capsule slightly S–shaped (Fig. 6).

Female genital plates : Genital plates triangular, with slight emargination near base; styli moderately developed and with few long setae (Fig. 7).

Body length: Male and female: 4.2 mm; Width: Male and female : 3.5 mm.

Holotype: Male, Himachal Pradesh: Shilli (1850m) 14.ii.1984.

Paratypes: 7♂♂, 7♀♀, same date and place as for holotype.

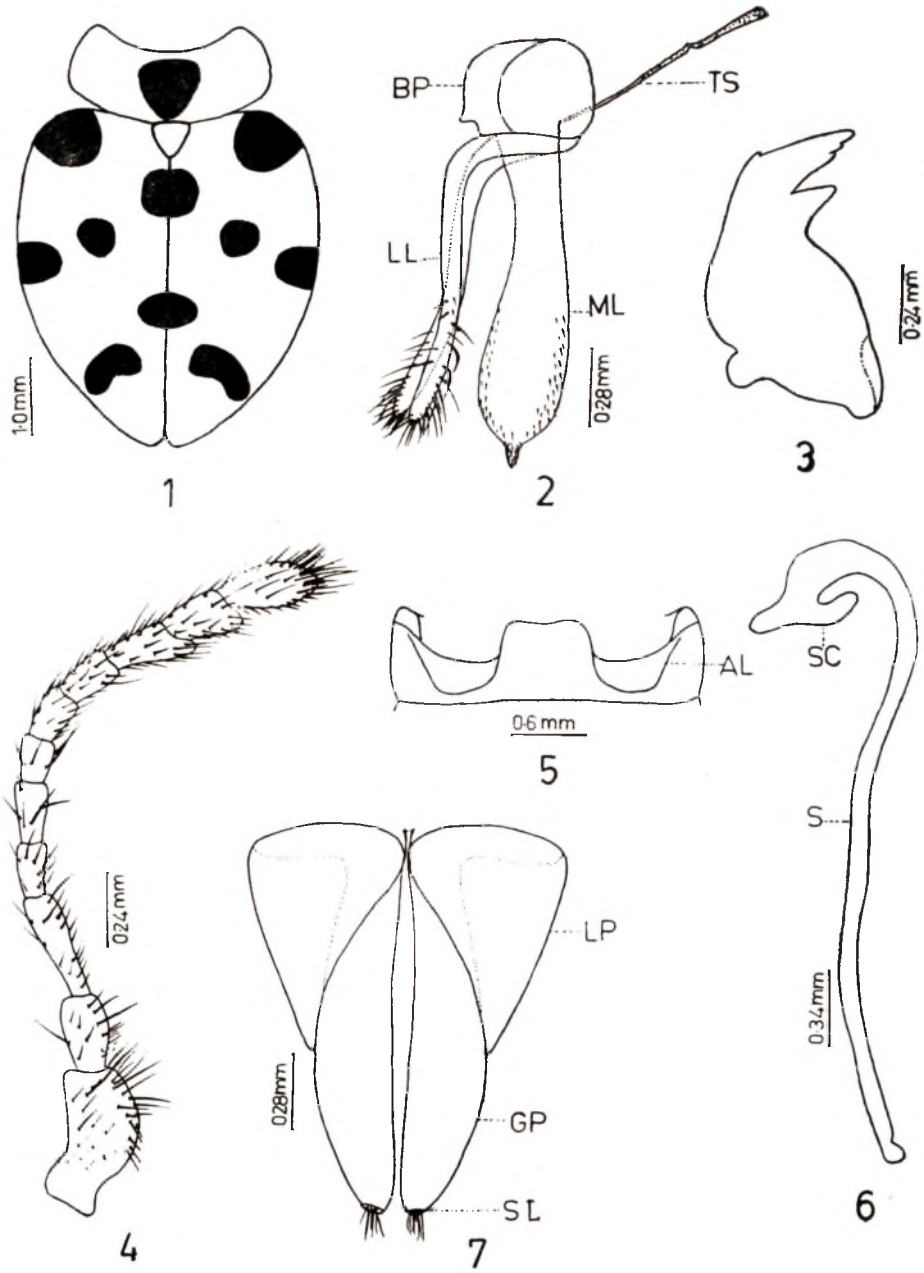
Remarks: This species closely related with *E. bengalica* Dieke in the pattern of elytral spots. In this species pronotum has a triangular spot in middle near frontal margin, whereas, in *E. bengalica*, pronotum provided with black longitudinal median spot, reaching from front edge to scutellum. Moreover male genitalia of both the species also differs. In *E. shilliensis* sp. nov., the median lobe first becomes swollen towards its terminal end and then abruptly ends into a pointed structure, whereas in *E. bengalica* (Dieke) narrowed down gradually.

The name of species is based on its type locality.

Epilachna convextata sp. nov.

♀ : Body oval, dorsum strongly convex; pubescence greyish white. Head reddish brown with dark brown apices of mandibles. Pronotum reddish brown with light yellow anterior corners and a median small and black spot situated close to anterior margin. Scutellum reddish brown. Elytra reddish brown with six elytral spots, arranged as 2,2,1,1. Scutellar spot continuous with its counterpart on other elytron to appear as triangular spot; humeral spot rounded and situated at the margin of humeral callus; median spot somewhat oval and situated on the median disc; median lateral spot rectangular and situated on the external margin; post-median spot situated on suture and continuous with its counterpart on other elytron to form an oval spot; sub-apical spot largest, rounded and situated slightly close to external margin (Fig. 8). Underside reddish brown with yellowish tinge except black lateral sides of metathorax, middle of elytral epipleurae and abdominal sternites.

Head half of pronotal width; punctation fine, sparse and defined; pubescence indistinct; antenna longer than width of head, 1st segment largest and robust, 3rd almost twice



Epilachna shilliensis sp. nov. Fig. 1. Body outline; 2. Tegmen (male genitalia) lateral view; 3. Mandible; 4. Antenna; 5. Abdominal sternite (1st) showing abdominal lines; 6. Sipho (male genitalia); 7. Female genital plates.

ABBREVIATIONS USED

BP—Basal piece; TS—Tegminal strut; ML—Median lobe; LL—Lateral lobes; SC—Siphonal capsule; S—Sipho; AL—Abdominal lines; GP—Genital plate; LP—Lateral plate.

to 2nd, last three segments form serrate club, segment 11 longer and truncate apically (Fig. 9); mandible with one tridentate apical tooth and two median teeth, dentules distinct (Fig. 19). Pronotum slightly more than half of body width, moderately emarginate anteriorly, lateral margins broadly rounded; anterior corners rounded, whereas, posterior corners angulate; punctation fine, close and defined pubescence small and dense. Scutellum equilaterally triangular; punctures few and fine; pubescence dense. Elytra with widely rounded humeral angles and hardly distinct humeral callus, apex rounded; punctation double: coarse punctures larger, sparse and well defined, whereas fine punctures close and defined; pubscence small and dense.

Underside with elytral epipleurae not foveate. Prosternum with wide processes and non-carinated. Mesosternum with anterior margin slightly incurvate. Metasternum with slightly excurvate anterior margin. Tarsal claw bifid without basal tooth. Abdominal lines regular, complete and rounded (Fig.11). Apical margin of last visible abdominal sternite rounded in female.

Female genital plates: Genital plate narrow at ends and broad at middle; stylus moderately developed with few setae (Fig. 12).

Male: Unknown.

Body size: Female: Length: 8.0 mm; Width: 5.25 mm.

Holotype: Female, West Bengal: Kalimpong (1250m). 7.v.1987.

Paratype: 2 ♀ ♀, same date and place as holotype.

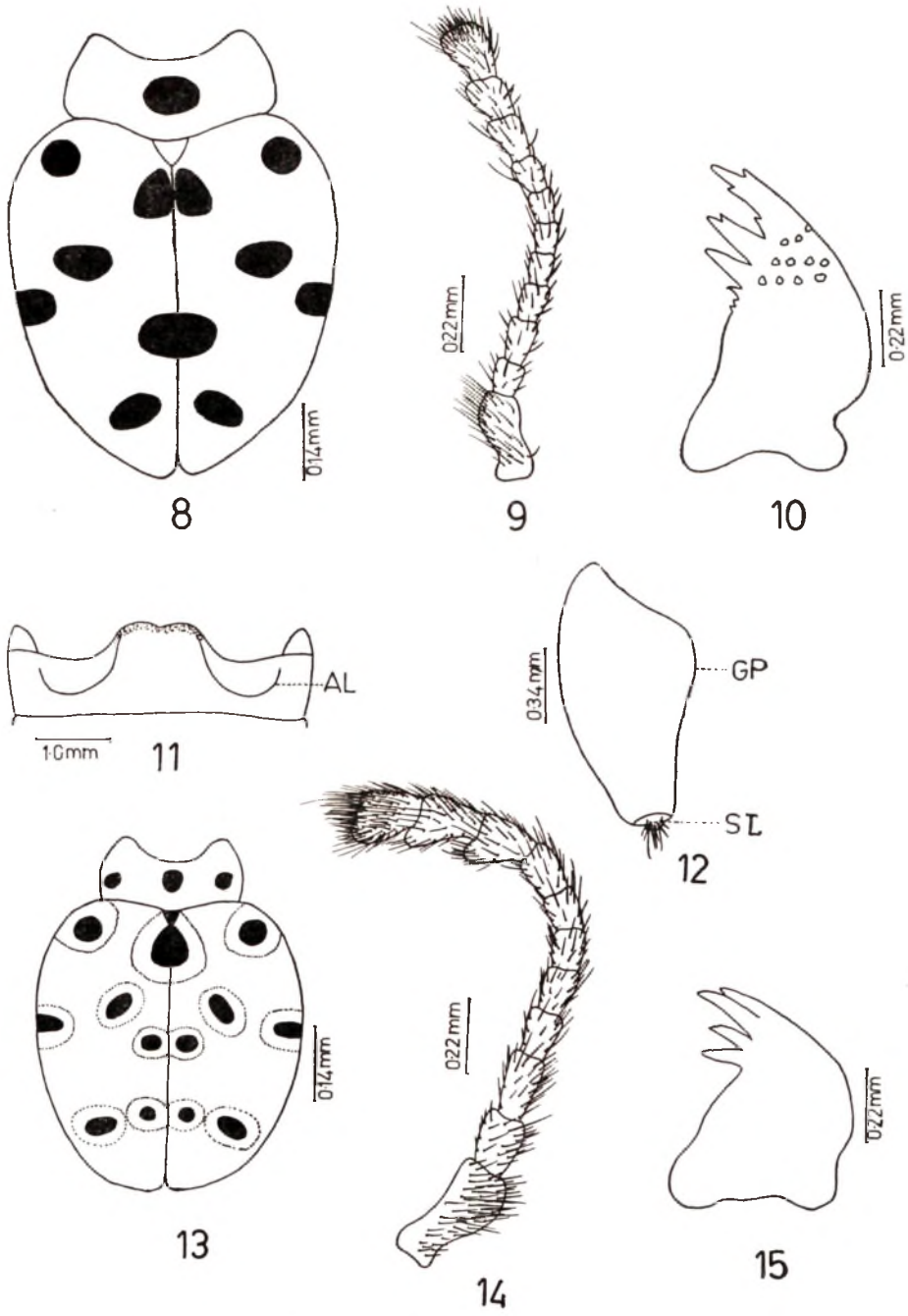
Remarks: This species closely resembles *Epilachna sexpustulata* Bielawski (1979) in elytral and pronotal spot pattern, but can be separated out on the basis of a small pronotal spot and median lateral spot not touching external margin. The species is named after the convexity of dorsum.

Female genitalia of *E. sexpustulata* has not been described by Bielawski (1979), hence no comparison.

Epilachna septemocellata sp. nov.

♀: Body elongate, oval and convex most so in middle, pubescence silvery white but black on black spots. Head reddish brown with piceous apices of mandibles. Pronotum reddish brown with three black spots, situated on median transverse line. Scutellum black. Elytra with seven black spots arranged as 2,3,2. Each spot surrounded by a light brown ring of moderate width. Remaining area dark brown to piceous. Scutellar spot situated on suture and joins with its counterpart on other elytron to form a triangle; humeral spot oval and occupying humeral callus; discal spot rounded, and situated at level of sutural margin of humeral spot; median lateral spot rounded and touching external margin; sub-post median spot subtriangular and close to suture; sutural post-median spot smallest, rounded and situated at same level as sub post-median spot; lateral post-median spot somewhat oval and placed away from external margin (Fig. 13). Sometimes apical spot present without brownish ring and resembles the ground colour of elytra. Underside black with reddish brown elytral epipleurae, prosternum, mesosternum, legs and lateral border of abdominal sternites.

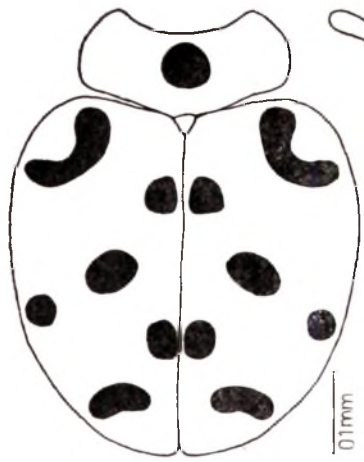
Head slightly more than half of pronotal width, punctation mixed: fine punctation close and moderately defined, whereas, coarse punctation well-defined and only on vertex; pubescence small and sparse; antenna longer than width of head, 1st segment largest and swollen, 3rd slightly longer than 2nd; segments 4 to 8 subequal, last three form serrate club, segment–11 truncate apically (Fig. 14); mandible with two apical teeth



Epilachna convextata sp. nov. Fig. 8. Body outline; 9. Antenna; 10. Mandible; 11. Abdominal sternite (1st) showing abdominal lines; 12. Female genital plate. *Epilachana septemocellata* sp. nov. Fig. 13. Body outline; 14. Antenna; 15. Mandible.

ABBREVIATIONS USED

AL—Abdominal lines.; GP—Genital plates; SL—Stylus.



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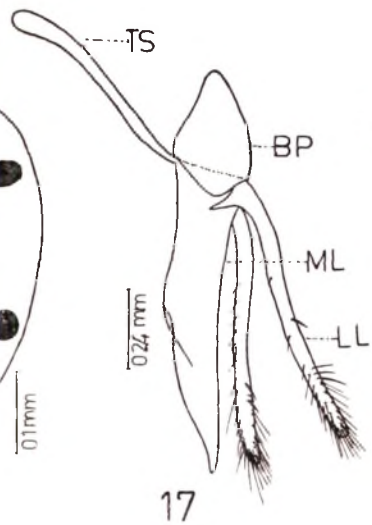

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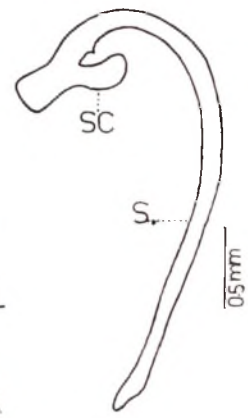

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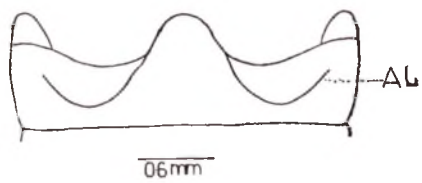

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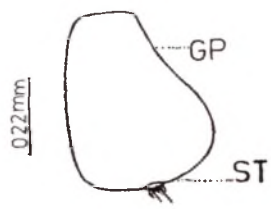

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Epilachna crecentomaculata sp. nov. Fig. 16. Body outline; 17. Tegmen (male genitalia) lateral view; 18. Sipho; 19. Antenna; 20. Abdominal sternite (1st) showing abdominal lines; 21. Mandible. *Epilachna septemocellata* sp. nov. Fig. 22. Abdominal sternite (1st) showing abdominal lines; 23. Female genital plate.

ABBREVIATIONS USED

BP—Basal piece; TS—Tegminal strut; ML—Median lobe; LL—Lateral lobes; SC—Siphonal capsule; S—Sipho; AL—Abdominal lines; GP—Genital plates SL—Stylus.

and two median teeth, non serrated (Fig. 15). Pronotum approximately 3/5th of body width, distinctly narrower anteriorly, lateral margins somewhat straight, anterior angles narrowly rounded, whereas, posterior ones obtusely rounded; punctation very fine, close and defined; pubescence similar to head. Scutellum equilaterally triangular; pubescence thin and sparse. Elytra oblong with humeral angles broadly rounded and distinct humeral callus, lateral margin bordered to form channel and slightly incurvate in middle, apex obtusely rounded; punctation mixed; fine punctation close and moderately defined, whereas, coarse punctures sparse and well defined; pubescence small and dense.

Underside with elytral epipleurae not foveate. Prosternum with very wide processes and carinated. Mesosternum with anterior margin slightly incurvate. Metasternum with very fine and sparse punctation. Tarsal claw bifid without basal tooth. Abdominal lines complete, almost terminal and broadly rounded (Fig. 22). The apical margin of last visible abdominal sternite rounded in female.

Female genital plates: Genital plates broadly rounded apically, overlapping with narrow basal parts; styli poorly developed (Fig. 23).

Male : Unknown

Body length: Female : Length : 7.5 mm; Width : 5.25 mm

Holotype: Female, Himachal Pradesh: Shilli (1200m); 14.9.1984.

Paratype: 2 ♀ ♀, same date and place as holotype.

Remarks:

An exceptional species of this genus, where elytral spots are sorrounded by light brown rings as in *Henosepilachna ocellata* Redt. Female genital plate of *H. ocellata* and *E. septemocellata* are markedly different. In former the plate is semicircular and in latter roughly like an end of an oar.

The name of this species is based on seven ocellus-like elytral spots.

Epilachna crecentomaculata sp. nov.

♂: Body somewhat oval, dorsum convex; pubescence silvery white. Head reddish brown with dark brown apices of mandibles. Pronotum reddish brown with light yellow anterior corners and small rounded median spot, situated close to anterior margin. Scutellum reddish brown. Elytra reddish brown with six black spots arranged as 2:2:1:1. Scutellar spot rounded, close to suture and far from apex of scutellum; humeral spot half-moon shaped; median spot rounded and situated on median disc; median lateral spot rounded and hardly touching external margin; post median spot rounded and lying very close to suture; subapical spot slightly curved but strip-like and close to external margin (Fig. 16). Underside black with reddish brown prosternum-legs and lateral border of 3,4 and 5th abdominal sternites.

Head slightly more than half of pronotal width; punctation fine, sparse and defined; pubescence thick and sparse; antenna almost equal to head width, 1st segment large and swollen, 3rd longer than 2nd, last three segments form serrate club and last one truncate apically (Fig. 19); mandible with one bifid apical tooth and one median tooth, none serrated (Fig. 21). Pronotum 3/5th of body width, highly emarginate anteriorly, lateral margins widely rounded, anterior corners sharply rounded, whereas, posterior

corners widely rounded; punctation fine close and defined; pubescence small and sparse. Elytra elongate with moderately distinct humeral callus and broadly rounded humeral angles, apex rounded; punctation double; Coarse punctures well defined and sparse; fine punctures close and poorly defined; pubescence small and dense. Scutellum equilaterally triangular; punctures few; pubescence small and thin.

Underside with elytral epipleurae not foveate. Prosternum with moderately long processes. Mesosternum with slightly incurvate anterior margin. Metasternum with much excurvate anterior margin. Abdominal lines complete, terminal and widely rounded (Fig. 20). The apical margin of last visible abdominal sternite slightly emarginate in male. Male genitalia: Tegmen moderately developed. Median lobe well developed, of uniform width upto middle then sharply narrowed to a pointed needle–like tip; setae absent. Lateral lobes slender and slightly smaller than median lobe, of uniform width; apex with small and few setae. Tegminal strut gradually wider towards distal end. Basal piece somewhat triangular (Fig. 17). Sipho rounded from base and of uniform width; siphonal capsule with outer arm well developed (Fig. 18).

Female : Unknown.

Body length: Male length : 5.25 mm. width : 4.25 mm

Holotype: Male, Himachal Pradesh: Barkot (2120 m) 3.v.1987.

Paratype: 1 male, same date and place as holotype.

Remarks: This species can easily be characterised by the moon-shaped humeral spots on elytra.

The species is named on the basis of moon-shaped humeral spot.

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TWO NEW SPECIES OF THE GENUS *PISAURA* SIMON (ARANEAE: PISAURIDAE) FROM COASTAL ANDHRA PRADESH, INDIA

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Two new species of spider genus *Pisaura* Simon (Pisauridae) viz., *Pisaura decorata* and *P. podilensis* are described in detail and illustrated, from Guntur and Prakasam Districts of Coastal Andhra Pradesh, India.

(*Key words* : two new spiders, *Pisaura decorata* and *P. podilensis*, Guntur, Prakasam, Andhra Pradesh, India)

The first record of Indian pisaurid spiders was made from India by Stoliczka in 1869 and thereafter through a series of publications of Cambridge (1877, 1885), Simon (1888, 1897, 1898), Thorell (1891, 1895), Pocock (1900) and Caporiacco (1935), as many as 13 species belonging to 9 genera were described. Recently Tikader (1970, 1977) and Tikader and Malhotra (1976) added another two new species, one each from *Pisaura* Simon and *Tinus* Camb. from Sikkim, West Bengal and Andaman & Nicobar Islands and redescribed two species of genera *Eucamptopus* Pocock and *Euprosthenops* Pocock raising a total of 15 species belonging to 10 genera. The tenth genus *Tinus* Camb. was recorded for the first time from Sikkim by Tikader (1970). While examining the spider collections made by one of us (TSR) from coastal Andhra Pradesh, we came across two new species of the genus *Pisaura* Simon, which are described here.

The type specimens will in due course be deposited in the National Collections of Zoological Survey of India, Calcutta.

1. **Pisaura decorata** sp. nov. (Fig. 1, a–d)

General: Cephalothorax and abdomen brown, legs greenish-brown. Total length 15.00 mm. Carapace 6.50 mm long, 5.65 mm wide; abdomen 9.15 mm long, 5.00 mm wide.

Cephalothorax : Longer than wide, convex, narrowing in front, clothed with thick fine hairs. Cephalic region is slightly high, lateral margins provided with longitudinal brown patches and the centre of the thorax provided with a conspicuous fovea. Eyes in two rows, anterior and posterior. Anterior row short, slightly recurved, anterior medians larger than anterior laterals. Posterior row of eyes more recurved than anterior row, posterior median and posterior lateral eyes are nearly equal in size and base of all the eyes encircled by black patch. Ocular quad nearly as long as wide as in Fig. 1 a. Clypeus narrow. Sternum heart-shaped, pointed behind, clothed with hairs. Labium and maxillae longer than wide, distal ends clothed with scopulae. Sternum, labium and maxillae as in Fig. 1 b. Chelicerae strong, inner and outer margins of fang furrow provided with three teeth each. Legs greenish brown; tibiae and metatarsi of all the legs provided with four and three pairs of ventral spines respectively. Leg formula 1 4 2 3.

Male: Unknown.

Abdomen : Brownish, longer than wide, clothed with thick hairs. Dorsum of abdomen provided with two pairs of sigillae. Lateral side of abdomen provided with two longitudinal whitish bands. Anterior mid-dorsal half of abdomen provided with a lens shaped light brown patch as in Fig. 1 a. Ventral side pale in colour. Epigyne and internal genitalia are as in Fig. 1 c and d. **Holotype:** 1 ♀ **paratype** : 1 ♀ in spirit.

Type locality : Valiveru, Dist. Guntur, 11. xii. 1986. Coll. T. S. Reddy.

Diagnosis : This species resembles *Pisaura gitae* Tikader but it is separated as follows : (i) Ocular quad nearly as long as wide but in *P. gitae* ocular quad longer than wide and wider behind than in front. (ii) Dorsum of abdomen provided with two pairs of sigillae but in *P. gitae* dorsum of abdomen without sigillae. (iii) Lateral side of abdomen provided with two longitudinal whitish bands but in *P. gitae* lateral side of abdomen provided with only one whitish band and anterior half with whitish two lines only. (iv) Epigyne and internal genitalia are also structurally different.

2. Pisaura podilensis sp. nov. (Fig. 2, a–g)

General : Cephalothorax and abdomen yellowish to deep brown, legs brownish green. Total length 9.20 mm. Carapace 3.75 mm long, 3.20 mm wide; abdomen 5.80 mm long, 3.20 mm wide.

Cephalothorax: Longer than wide, narrowing in front, clothed with thick fine hairs. Cephalic region is very slightly high, middle of the cephalothorax provided with a longitudinal brown patch and the centre of the thorax provided with a conspicuous fovea. Eyes in two rows, anterior and posterior. Anterior row short, slightly procurved and base of anterior laterals having black patch. Posterior row of eyes recurved, posterior median and posterior lateral eyes are nearly equal in size and base of all the eyes encircled by black patch. Ocular quad longer than wide and narrowing in front as in Fig. 2 a. Sternum heart-shaped, pointed behind, clothed with hairs, middle with yellowish in colour. Labium and maxillae longer than wide and light brown in colour. Sternum, labium and maxillae as in Fig. 2b. Chelicerae strong, inner and outer margins of fang furrow provided with three and two teeth respectively. Legs brown, I and II longer than III and IV. Tibiae and metatarsi of I and II provided with four and three pairs of ventral spines respectively. Tibiae

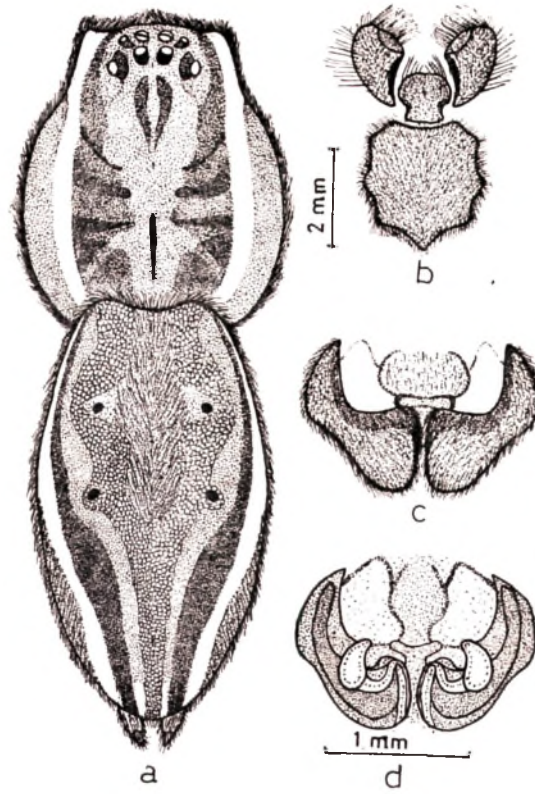

Fig. 1. *Pisaura decorata* sp. nov. a—Dorsal view of female (legs omitted); b—Sternum, labium and maxillae; c—Epigyne; d—Internal genitalia.

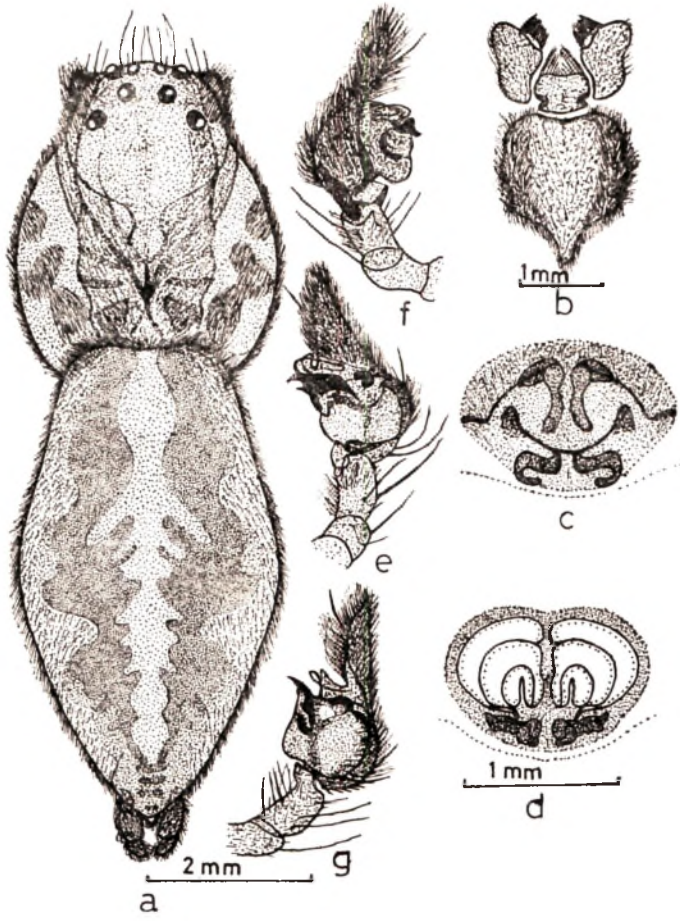

Fig. 2. *Pisaura podilensis* sp. nov. a—Dorsal view of female (legs omitted); b—Sternum, labium and maxillae; c—Epigyne; d—Internal genitalia; e—Right male palp – ventral view; f—Right male palp – outer view; g—Right male palp – inner view.

and metatarsi of III and IV provided with three and two pairs of ventral spines respectively. Leg formula 1 4 2 3.

Male : It is similar to the female and nearly equal in size. Male total length 9.30 mm. Male palp as in Fig. 2 e, f and g.

Abdomen : Yellowish to deep brown, longer than wide, clothed with hairs middle of abdomen provided with a longitudinal deep brown patch and lateral sides provided with white and brown markings as in Fig. 2 a. Ventral side pale in colour, clothed with fine hairs. Epigyne and internal genitalia as in Fig. 2 c and d.

Holotype : 1 ♀ **paratype :** 1 ♀, *allotype* : 1 ♂ in spirit.

Diagnosis : This species resembles *Pisaura decorata* sp. nov. but it is separated as follows : (i) Middle of the cephalothorax provided with a longitudinal brown patch but in *P. decorata* lateral margins provided with longitudinal brown patches. (ii) Anterior row of eyes short, slightly procurved but in *P. decorata* anterior row short, slightly

recurved and anterior medians larger than anterior laterals. (iii) Ocular quad longer than wide but in *P. decorata* ocular quad nearly as long as wide. (iv) Abdomen yellowish to deep brown, mid-dorsally provided with a longitudinal deep brown patch and lateral sides with white and brown marking but in *P. decorata* abdomen brownish, anterior mid-dorsally provided with a lens shaped light brown patch and lateral sides with two longitudinal whitish bands. (v) Epigyne and internal genitalia are also structurally different.

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The authors are grateful to Prof. K. B. TIPNIS, Principal, Sir P.P. Institute of Science, Bhavnagar University, Bhavnagar for providing the laboratory facilities. The financial assistance to one of us (TSR) by the Government of Gujarat is acknowledged.

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A NEW SPECIES OF *AMAURORIUS* KOCH (ARANEAE: AMAUROBIIDAE) FROM COASTAL ANDHRA PRADESH, INDIA

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A new spider species *Amaurobius andhracus* (Amaurobiidae) is described in detail and illustrated here. It was collected from all the nine districts of coastal region of Andhra Pradesh during the years 1984-1988.

(*Key words*: *Amaurobius andhracus* sp. nov., coastal Andhra Pradesh)

The earliest records of spider species belonging to this family Amarobiidae from India are of Caporiacco (1934) and Reimoser (1934) where they described three new species from two different genera.

Recently Patel and Patel (1972) described, the genus *Amaurobius* for the first time from India and described a new species. Later, Tikader (1977) described a new species of this genus from Andaman, making a total of two species of this genus. While examining the spider collections made from coastal Andhra Pradesh we came across a new species of *Amaurobius* which is described and illustrated here, which makes a total of three species.

The type specimens will in due course be deposited in the National collections of Zooloical Survey of India, Calcutta.

Amaurobius andhracus sp. nov. (Fig. 1,a-h)

General: Cephalothorax and legs reddish brown, abdomen brown. Total length 8.50 mm. Carapace 4.10 mm long, 2.50 mm wide; abdomen 4.50 mm long, 3.10 mm wide.

Cephalothorax: Longer than wide, reddish brown, clothed with hairs, cephalic region high; centre of the thoracic region provided with a fovea and radiating streaks. Eyes in two rows. Anterior row procurved anterior medians slightly smaller than the anterior laterals; posterior row slightly recurved, posterior laterals larger than the posterior medians. Ocular quad as long as wide, slightly narrowing in front as in Fig. 1a. Sternum reddish, heart shaped, pointed behind, clothed with hairs. Labium and maxillae reddish brown, longer than wide. Sternum, labium and maxillae as in Fig. 1 b. Chelicerae strong, stout with very small fang. Legs thin, long, clothed with fine hairs and spine – like hairs. Tibiae and metatarsi of leg I with five and three pairs of ventral spines respectively. Metatarsi of leg IV provided with calamistrum as in Fig. 1 g.

Male: Male is smaller than the female and of same colour pattern. Total length 6.50 mm. Male palp as in Fig. 1 e and f.

Abdomen : Oval, longer than wide, clothed with hairs, slightly overlapping the posterior region of cephalothorax in front. Upper portion of abdomen not provided with any chitinous collar. Dorsum of abdomen brown with irregular pale yellow spots, and the middle provided with three

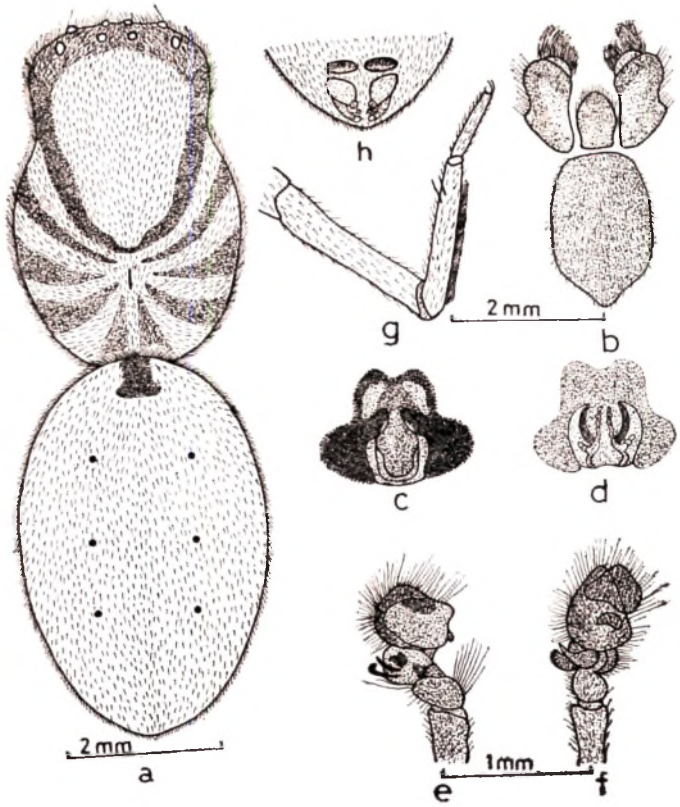

Fig. 1. *Amaurobius andhracus* sp. nov. a—Dorsal view of feamale (legs omitted); b—Sternum, labium and maxillae; C—Epigyne; d—Internal genitalia; e—Right male palp–ventral view; f—Right male palp–dorsal view; g—Calamistrum; h—Cribellum.

pairs of small brown sigillae like patches as in Fig. 1 a. Ventral side pale in colour than the dorsal. Abdomen ventrally provided with cribellum just in front of spinnerets as in Fig. 1 h. Epigyne and internal genitalia as in Fig. 1 c and d.

Holotype: 1♀ **paratype:** 66♀ **allotype:** 2♀ in spirit Type- locality: Eluru, Dist. West Godavari, 1. ix. 1985. Coll. T.S. Reddy.

Distribution: Known from the type locality and all the nine Districts of coastal Andhra Pradesh.

Diagnosis: This species resembles *Amaurobius andamanensis* Tikader but it is separated as follows: (i) Cephalothorax longer than wide, clothed with hairs, cephalic region high; centre of the thoracic region provided with a fovea but in *A. andamanensis* cephalothorax longer than wide, smooth practically devoid of haris or spines, central region of cephalothorax high and sloping in all the directions (ii) Upper portion of abdomen not provided with any chitinous collar but in *A. andamanensis* upper portion of abdomen provided with a chitinous collar (iii) Epigyne and internal genitalia are also structurally different.

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The authors are grateful to Prof. K. B. TIPNIS, Principal, Sir P. P. Institute of

Science, Bhavnagar University, Bhavnagar for providing the laboratory facilities. The financial assistance to one of us (TSR) by the Government of Gujarat is acknowledged.

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EVALUATION OF THE EXOTIC PREDATOR *CRYPTOLAEMUS MONTROUZIERI* MULS. (COCCINELLIDAE, COLEOPTERA) IN THE SUPPRESSION OF GREEN SHIELD SCALE, *CHLOROPULVINARIA PSIDII* (MASKELL) (COCCIDAE, HEMIPTERA) ON GUAVA

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The scale *Chloropulvinaria psidii* (Maskell) is a serious pest of guava, *Psidium guajaua* L. in India. The coccinellid predator *Cryptotaemus montrouzieri* Muls. was found to be a voraceous feeder of the scale consuming 3766 eggs in its larval development of 17.60 days under laboratory conditions. In the field, releases of the exotic coccinellid predator *C. montrouzieri* effectively suppressed *C. psidii*. Besides *C. montrouzieri*, *Scymnus coccivora* Ayyar and *Coccophagus cowperii* Grlt. were also recorded in negligible numbers.

(*Key words*: evaluation, *Cyrptolaemus montrouzieri*, guava, scale, *Chloropulvinaria psidii*, predator)

INTRODUCTION

The green shield scale, *Chloropulvinaria* (= *Pulvinaria*) *psidii* Maskell occurs throughout India (ALAM, 1962). Infestation of guava plants by *C. psidii* in India has been documented by EASWARAMOORTHY & JAYARAJ (1977) and PAWAR *et al.* (1984). The scales occur on the fruits, leaves, shoots and trunk. They secrete honey dew resulting in development of sooty mould and thereby hindering of photosynthetic activity. According to FLETCHER (1914), severe scale infestation could kill the plants. PUTTARUDRIAH & CHANNA BASAVANNA (1957) and MANJUNATH (1986) reported the feeding of the predator *Cryptolaemus montrouzieri* Muls. on *C. psidii* on guava around Bangalore. The present study was undertaken to evaluate the efficacy of *C. montrouzieri* in the control of *C. psidii* in guava orchards.

Contribution No. 177/88, of I.I.H.R.

MATERIALS AND METHODS

The predator *C. montrouzieri* was reared on the mealybug (*Planococcus citri* (Risso) infested pumpkin fruits in the laboratory at 25–27°C and 50–60% relative humidity.

Newly hatched predatory larvae (20) were confined individually in glass vials (5.5 × 2.5 cm) and supplied with 100, 200, 300 and 500 fresh eggs of *C. psidii* daily to the four larval instars respectively. The number of eggs consumed daily by the predator in each larval instar were recorded and as such the total number consumed in its larval development were calculated.

The field trials were conducted in two guava orchards at I.I.H.R. Farm in 1987. The first trial was carried out on 160 guava plants of two and one-half years old. Severe infestation of the scale was first observed in April. Since the infestation occurred

throughout the orchard, adults *Cryptolaemus* were released, 10 per plant. The population of ovisacs, nymphs + adult scales and *Cryptolaemus* larvae were recorded on 10 randomly selected plants at fortnightly intervals. In each plant, 4 shoots, one shoot in each direction, were chosen for observation.

In another trial there were 800 plants of three years old but the scale infestation was observed only on 12 plants. To confine the predatory activity on the infested plants. *C. montrouzieri* larvae (3–5 days old) were released, 10 per plant in January and again 15 days later. Fortnightly observations were recorded on the population of scales and ovisacs on all the infested plants.

RESULTS

The average number of eggs consumed by the first, second, third and fourth instar larvae of *C. montrouzieri* averaged 333.40, 273.20, 798.40 and 2361.00 respectively. A mean total of 3766 eggs of *C. psidii* was consumed by the grub during its developmental period of 17.60 days in the laboratory (Table 1).

TABLE 1. Feeding potential and development of *Cryptolaemus montrouzieri* on *Chloropulvinaria psidii*.

Larval instar of *Cryptolaemus*	No. of *Chloropulvinaria eggs* consumed (Mean ± SD)	Developmental period of *Cryptolaemus* (*days*) (Mean ± SD)
I	333.40 ± 13.41	4.20 ± 0.45
II	273.20 ± 19.27	2.40 ± 0.55
III	798.40 ± 21.10	4.40 ± 0.50
IV	2361.00 ± 138.31	6.60 ± 0.58
Total	3766.00 ± 145.84	17.60 ± 0.89

SD Standard deviation

In block no. 9, mean populations of 56.8 scales (nymphs + adults) and 88.7 ovisacs per plant were recorded prior to the release of *Cryptolaemus* (Table 2). Larval activity first noticed 15 days after release and continued throughout the study period. Higher population of *Cryptolaemus* larvae (10.2 to 17.8 per plant) were observed in July and August. The scale population was reduced to negligible numbers (0.3 – 0.9) by October end. During the study period besides *C. montrouzieri* another coccinellid *Scymnus coccivora* Ayyar and the aphelinid parasitoid, *Coccophagus cowperii* Grlt. were recorded but their role was insignificant.

In block no. 2 the scale population was low even prior to the release of *C. montrouzieri*. The effect of the release of the predator is given in (Table 3). The population declined from 10.5 nymphs in January to 0.18 during the first week of March 1987. The activity of *Cryptolaemus* was observed throughout the study period.

DISCUSSION AND CONCLUSION

The larvae of *C. montrouzieri* are voraceous predators of *Chloropulvinaria* eggs. In the field, the predator proved effective against *C. psidii* in both the orchards. *Cryptolaemus* prefer to feed on the ovisacs rather than nymphs and adult scales. The effectiveness of the *C. montrouzieri* against *C. psidii* has also been reported by earlier workers in many countries on number of crops. WOLCOTT (1958) reported the establishment of *C. montrouzieri* upon the population of *C. psidii* attacking *Erythrina* in Puerto Rico. The same predator achieved good control of this scale on oleander, *Ficus* sp. and other ornamentals in several localised areas of Bermuda, (BENNETT & HUGHES, 1959).

Scymnus coccivora was reported as an effective predator of *Pulvinaria maxima*

TABLE 2. Field population of *Chloropulvinaria* and *Cryptolaemus* in block no. 9.

date of observation	population per plant (Mean ± SD)		
	Chloropulvinaria		*Cryptolaemus*
	ovisacs	nymphs ± adults	grubs
1. 15-4-87	56.8 ± 11.7	88.7 ± 47.9	0
2. 30-4-87	45.6 ± 14.1	57.8 ± 28.6	0.7 ± 0.8
3. 15-5-87	54.0 ± 11.1	68.5 ± 18.1	1.1 ± 1.1
4. 30-5-87	48.2 ± 17.3	66.6 ± 16.5	1.4 ± 1.3
5. 15-6-87	42.0 ± 20.7	74.0 ± 12.2	1.6 ± 1.7
6. 30-6-87	41.0 ± 20.2	64.3 ± 20.4	2.7 ± 1.9
7. 15-7-87	39.7 ± 17.4	51.1 ± 20.9	4.2 ± 1.5
8. 30-7-87	33.1 ± 14.9	35.7 ± 26.0	14.7 ± 2.1
9. 14-8-87	25.6 ± 18.2	40.6 ± 22.9	10.2 ± 1.8
10. 30-8-87	15.4 ± 10.8	37.3 ± 32.6	17.8 ± 3.7
11. 15-9-87	11.2 ± 10.4	21.9 ± 27.1	11.2 ± 7.5
12. 30-9-87	13.7 ± 6.3	23.5 ± 16.0	6.9 ± 4.2
13. 15-10-87	4.5 ± 5.8	12.8 ± 19.1	5.4 ± 8.8
14. 30-10-87	0.9 ± 1.3	0.3 ± 0.7	1.9 ± 0.9

SD = Standard deviation.

TABLE 3. Population of *C. psidii* and *C. montrouzieri* in the guava orchard at block no. 2.

date of observation	population of *C. psidii* (Mean ± SD)		*Cryptolaemus*
	nymphs + adults	ovisacs	grubs
20-1-87	10.55 ± 2.91	11.87 ± 1.81	0.0
3-2-87	4.25 ± 2.65	5.83 ± 1.24	2.0 ± 0.75
17-2-87	1.35 ± 1.29	2.38 ± 0.90	3.80 ± 1.12
2-3-87	0.18 ± 0.33	0.30 ± 0.31	0.25 ± 0.46

SD = Standard deviation.

Green (AYYAR, 1925). In the present study *S. coccivora* was observed only occasionally. The same coccinellid did not establish on *C. psidii* in Bermuda (BENNETT & HUGHES, 1959). The parasitoid *Coccophagus cowperii* on *C. psidii* was observed in the present study. Earlier, two parasitoid *Coccophagus bogoriensis* (Kon) and *Aneristus* sp. were collected from *C. psidii* in Bangalore (BENNETT & HUGHES, 1959). The introduction of *Microterys kotinskyi* (Full.) which was a key parasitoid in Bermuda can also be considered for the control of *C. psidii* in India.

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EFFECT OF CHILLING ON HATCHING AND PARASITISM OF EGGS OF *CORCYRA CEPHALONICA* (STAINTON) BY *TRICHOGRAMMA CHILONIS* (ISHII)[1]

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Effect of chilling (at – 5°C) on hatching and parasitism of the eggs of *Corcyra cephalonica* (Stainton) by *Trichogramma chilonis* (Ishii) was stuided. The age of the eggs and period of refrigeration were found to have multiple effect on hatching and parasitism by *T. chilonis*. As the period of refrigeration and age of the egg advanced hatching and parasitism decreased. Prolonged exposure of eggs to cold resulted in the death of embryo and reduced hatching. Fresh eggs were preferred over chilled eggs by the parasitoid. It was further noticed that chilling of eggs of different ages even for two hours considerably reduced their hatching and parasitism.

(*Key words*: refrigreration, chilling, hatching, parasitism, *Corcyra cephalonica*, *Trichogramma chilonis*)

INTRODUCTION

Under natural conditions, parasitoids have been found not giving complete control, most often due to their very low density in the field. The population of these natural enemies attacking pests can be increased directly by mass rearing and distribution of the insects (ANON, 1969). The parasitoid, *Trichogramma chilonis* attacks eggs of many species of Lepidoptera and has attracted the attention of many workers. Large number of these parasitoids can be successfully reared economically in small spaces under laboratory condition on suitable hosts. KUNHIKANNAN (1931) found it feasible to store parasitized eggs in the refrigerator when the delayed development of parasitoid is needed. SINGH (1969) conducted some experiments to reduce superparasitism and to check the hatching of unparasitized eggs, where he observed that storage of *Corcyra* eggs at 4°C for 16 to 76 h was found to kill the embryos maintaining the eggs in a state suitable for parasitoid rearing and acceptence to ovipositing by *Trichogramma* sp. In response to the increased demand for the supply of parasitoid cards, prolonged storage of eggs under chilled condition would be absolutely necessary to have continuous supply of *Corcyra* eggs. However, very little information is available on the age of the egg and period of exposure to chilled conditions. Hence, an attempt was made to study the effect of chilling period on hatching and parasitism on eggs of *C. cephalonica* of different age. Results are presented in this contribution.

MATERIALS AND METHODS

The present studies were conducted at the Department of Entomology, College of Agriculture, Dharwad during 1984–1985. *C. cephalonica* eggs 6, 12, 24, 48, and 72 hours old, were collected from laboratory culture and 200 eggs of each age group were released in different Petriplates (12 cm × 2 cm) in 3 replications and were kept in freezing chamber of

[1]Forms part of the thesis submitted by the first author to the University of Agricultural Sciences, Bangalore.

the refrigerator where the temperature was maintained at – 5°C with 60 per cent relative humidity. These eggs were chilled for 2, 4, 8, 12, 24, 48 and 72 hours and a batch of eggs of each age was kept unrefrigerated outside at room temperature and grouped in two batches for recording the percentages of hatching. The eggs after chilling for different periods, were kept at room temperature and grouped in two batches of 100 each. One batch of 100 eggs were pasted on a card (2.5 cm × 2.5 cm) with 10% gum arabic and exposed to adult *T. chilonis*. The parasitized and unparasitized eggs were counted after three days and percentage parasitism was worked out and compared with the parasitism of non-refrigerated eggs at normal room temperature. The experiment was replicated 3 times. Since the data was having extreme percentage the logit transformation (FINNEY, 1952) was adopted and was statistically analysed using analysis of variance.

RESULTS AND DISCUSSION

Results pertaining to the effect of age and chilling (at –5°C) period on hatching of the eggs of *C. cephalonica* are given in Table 1. When the eggs were chilled for a period of 2 h, a maximum of 54.73 (5.096) per cent of hatching while no hatching of eggs was observed when eggs were chilled for 48 and 72 h (Table 1). From the above it was noticed that advancement of period of chilling leads to death of embryos and non-hatching of eggs.

TABLE 1. Effect of age and chilling (at–5°C) period on hatching of the eggs of *Corcyra cephalonica* (St.) percentage of hatching.

Age of the eggs (in h)	Period of (chilling) (in h)							
	2	4	8	12	24	48	72	Average
6	5.220**	4.775	3.679	3.568	2.155	0.00	0.00	2.773
	(60.00)	(39.00)	(6.70)	(5.71)	(2.00)	(0.00)	(0.00)	(16.20)
12	5.182	5.020	4.006	1.987	0.901	0.000	0.00	2.585
	(59.00)	(51.00)	(12.25)	(3.50)	(1.00)	(0.00)	(0.00)	(18.11)
24	5.161	5.000	4.839	4.003	3.776	0.00	0.00	3.254
	(58.00)	(50.00)	(42.00)	(12.00)	(5.00)	(0.00)	(0.00)	(23.86)
48	5.100	5.100	4.305	3.927	0.00	0.00	0.00	2.633
	(55.00)	(55.00)	(20.00)	(10.50)	(0.00)	(0.00)	(0.00)	(20.07)
72	4.830	4.797	4.531	3.900	0.00	0.00	0.00	2.583
	(41.66)	(40.00)	(29.00)	(10.00)	(0.00)	(0.00)	(0.00)	(7.24)
Average	5.096	4.939	4.476	3.482	1.366	0.00	0.00	
	(54.73)	(47.00)	(21.99)	(8.34)	(1.60)	(0.00)	(0.00)	

S EM (period of chilling) ± = 0.12168 CD at 5% = 0.3427
S EM (age of the eggs) ± = 0.10282 CD at 5% = 0.4910
S EM (Interaction) ± = 0.2721 CD at 5% = 0.7127

** Logit transformed values. Figures within brackets are original values.

Age of the eggs also seemed to play an important role in hatching of the eggs when they were chilled for different period of time. When 24 h old eggs were stored under chilling conditions, percentage of hatching was found to be 23.86 (3.254) and it was 17.24 (2.583) percent in 72 h old eggs. This is due to the fact that by 24 hours the embryonic development would be faster. On the contrary, prolonged exposure of eggs of chilled condition would result in death of embryo.

The results of present studies are in line with results of SINGH (1969), who observed the death of embryos when chilled under –4° C for 16–76 h. Further, he opined that the age of eggs as well as the period of refrigeration are the twin major factors governing hatching. Irrespective of the age of the eggs, with the advancement of chilling period, there is a gradual decrease in hatching which may be due to adverse effect of cold on developing embryos. Results pertaining to the effect of the age of the egg and period of chilling (–5°C) on parasitism of eggs of *C. cephalonica* by *T. chilonis* are given in Table 2. Maximum percentage of parasitism was 61.62 (5.240) found in the eggs chilled for a period of 2 h whereas a minimum of 7.09 (3.778) per cent of the eggs were parasitized when chilled for a period of 72 h. (Table 2). From the above results it may be concluded that the prolonged exposure of aged eggs to the parasitoids results in poor parasitism. Fresh eggs when chilled for limited time hatched due to proper development of embryos and such eggs were preferred by parasitoids. The results of the present study are in line with the reports of HINDS & SPENCER (1930) and KRISHNAMURTHI (1938) who found greater percentage of parasitism in freshly laid eggs than older ones.

TABLE 2. Effect of age and chilling period on eggs of *Corcyra cephalonica* (St.) on parasitism by *Trichogramma chilonis* (Ishii).

Percentage of egg parasitism

Age of the eggs (in h)	Period of chilling (in h)							
	2	4	8	12	24	48	72	Average
6	5.376** (68.00)	4.480 (28.25)	4.425 (25.00)	4.358 (21.82)	4.200 (16.87)	4.046 (13.00)	4.161 (15.75)	4.435 (26.96)
12	5.343 (66.34)	4.556 (27.50)	4.150 (15.46)	4.114 (15.00)	3.895 (10.00)	3.693 (7.42)	3.850 (4.90)	4.229 (19.52)
24	5.197 (59.75)	4.525 (27.92)	4.050 (15.25)	3.881 (11.64)	3.985 (9.60)	3.499 (5.00)	3.98 (3.90)	4.099 (19.04)
48	5.141 (57.00)	4.980 (49.00)	4.623 (32.00)	4.364 (22.00)	4.450 (27.15)	4.128 (15.00)	4.238 (17.90)	4.561 (31.44)
72	5.141 (57.00)	4.658 (40.00)	4.425 (25.00)	4.405 (23.00)	4.502 (27.00)	3.901 (10.00)	3.242 (3.00)	4.345 (26.48)
Average	5.240 (61.62)	4.640 (34.54)	4.335 (22.54)	4.224 (18.76)	4.205 (18.12)	3.853 (10.08)	3.778 (7.09)	

S EM	(period of chilling)	± = 0.04775	CD at 5%	= 0.1344
S EM	(age of the eggs)	± = 0.0404	CD at 5%	= 0.1277
S EM	(Interation)	± = 0.10677	CD at 5%	= 0.3006

**Logit transformed values. Figures within bracket are original values of percentage of parasitism.

The maximum of 68.00 (5.376) per cent parasitism of eggs was noticed when 6 h old eggs were chilled for a period of 2 h. As the age of the eggs and chilling period advanced the percentage parasitism also decreased (Table 2). These results are in agreement with the reports of TORRE *et al.* (1972). The per cent parasitism was drastically reduced as the chilling period advanced upto 72h. The studies indicated that the age of the host egg and chilling period are the two prime factors responsible for parasitism. Prolonged exposure of 72 h old eggs adversely affected the development of the embryo and consequently low parasitism was noticed. This may be one of the reasons for non-acceptance of chilled eggs by parasitoids. The present results do not agree with the results obtained by SINGH (1969) where eggs were chilled at –4°C (with unknown humidity level at which the experiment was conducted). HINDS & SPENCER (1930) reported that the eggs when stored for about a month at 5.5 to 12.8°C temperature can be used for parasitism.

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SPATIAL DISTRIBUTION PATTERN OF EGGS OF *EARIAS VITTELLA* FABRICIUS IN OKRA FIELD

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Eggs of shoot and fruit borer, *Earias vittella* Fab. in nine quadrats of an okra field at seven different dates followed a negative binomial distribution. The variance to mean ratio, k and χ^2 (chi-square) values also showed clumped behaviour of the insect. Clump distribution of *Earias* eggs may result from environmental heterogeneity. The outer (border) rows tend to receive more eggs than do the central rows. Data on vertical distribution within plant showed that ovipositing *Earias* females placed maximum eggs on buds at the top plant canopy. The eggs were distributed singly but clolonies were aggregated.

(*Key words*: spatial distribution, linear regression, *Earias vittella*)

INTRODUCTION

The description of distribution of a population is of considerable ecological significance. The study of distribution pattern of a population is helpful in establishing relationship between density and various factors affecting mortality. In pest population studies the precision of population estimates based on a given sampling plan depends both upon the characteristics of the species in terms of its density and degree of aggregation and also upon the characteristics of the sampling technique. The distribution pattern provides information about the behaviour of population besides providing a base for developing a sound sampling plan. Thus the adequate knowledge of the distribution pattern of insect counts gives an insight to formulate successful pest management strategies.

The shoot- and fruit-borer, *Earias vittella* F. is one of the key pests of okra in India and Far Eastern Countries. LEFROY (1906) was the first to report it as a pest on okra from India. Since then it has acquired the status of a serious pest and is reported to damage 3.5 to 90% in different cultivars. So far the research work on *E. vittella* has been restricted to incidence, biology, feeding behaviour, varietal susceptibility and control (SRINIVASAN & GOWDER, 1958: PANT & GUPTA, 1959; KASHYAP & VARMA, 1983; SRINIVASAN & KUMAR, 1983). In the present paper efforts have been made to study the horizontal and vertical distribution of eggs of *E. vittella* in okra field at various time intervals.

MATERIALS AND METHODS

An unprotected crop of okra cultivar 'Pusa-Sawani' was raised in an area of 225 sq.m (15 m × 15 m) at the Hessaraghatta research farm of Indian Institute of Horticultural Research, Bangalore. The field was divided in 9 uniform strata as suggested by HARCOURT (1961) and absolute counts of eggs on ten plants in each stratum were recorded. Seven such observations were recorded during the crop season commencing from 30 days after sowing. In another set of observations, the field was divided in three quadrats viz., outer, middle and inner each three metre wide and counts of eggs on 40

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randomly selected plants in each quadrat were recorded. Vertical distribution was determined by dividing plant canopy vertically into two levels viz., upper half and lower half and counting borer eggs at each level on 90 randomly selected plants when the population was at its peak (60 days after sowing).

The procedure outlined by SOUTHWOOD (1978) was followed for determining the distribution pattern. Three dispersion parameters viz., variance to mean ratio, exponent k of the negative binomial and number of units in the aggregation (BLISS & FISHER, 1953; ANSCOMBE, 1949, 1950; ARBOUS & KERRICH, 1959) were worked out. LLOYD's (1967) index of patchiness, which is the ratio of mean crowding (m*) to mean density (m) was also calculated for each set of observations. The value of mean crowding (m*) with estimates based on samples was calculated by

$$m^* = m \left(+ \frac{S^2}{m} - 1 \right)$$

where, m = mean; S^2 = variance.

The value of the index equals unity in a random distribution but is greater and smaller than unity in contagious and regular distributions, respectively.

IWAO's (1968) patchiness regression, which gives a linear relationship between mean crowding (m*) and mean denity (m) over a series of densities ($m^* = \alpha + \beta m$) was calculated. Iwao termed the intercept, α, the index of basic contagion and the slope, β, the density contagiousness coefficient. The distributed pattern is contagious if $\beta > 1$ and $\alpha \geq 0$, or $\beta = 1$ and $\alpha > 0$. The pattern is regular if $\beta < 1$ and $\alpha = 0$, or $\beta = 1$ and $\alpha < 0$.

Among the models of contagious distributions, the negative binomial is perhaps the most widely applied to insect populations (ANSCOMBE, 1949; WADLEY, 1950; EVANS, 1953; BLISS & OWEN 1958; WATERS, 1959; SUMAN *et al.*, 1980 a,b). An important aspect of this distribution is that the variance is greater than the mean. The smaller the value of k, the greater the degree of dispersion and vice-versa. The goodness of fit of k for fitting negative binomial and Poisson distributions were carried out using chi-square statistics.

RESULTS AND DISCUSSION

Horizontal distribution: The results on the distribution pattern of eggs of *E. vittella* on okra plant on different dates after sowing are summarised in Table 1. The mean values of counts increased with the advancement of time. The variances were higher with higher mean counts indicating the dependence of former on the latter. The variance to mean ratios were invariably greater than unity on all the dates of observations. This implied that distribution pattern of eggs was of contagious type, showing thereby the habit of aggregation in the species.

This type of distribution can be adequately expressed by the negative binomial distribution (SOUTHWOOD, 1978) which is described by the mean and exponent k-a measure of amount of clumping. According to SOUTHWOOD (1978), if k is greater than eight, the clumping is low and there is tendency towards randomness; on the other hand, low k values indicate high amount of aggregation. The coefficient of dispersion (k) as obtained by fitting negative binomial distribution ranged between 0.76 to 3.08 except for date 31.1.1986 where value is 5.30, an abnormal case which may be due to sampling error. It is evident that mostly the values of exponent k were between 1 and 3, which indicated that there was a high degree of aggregation in majority of the cases.

TABLE 1. Statistical parameters for egg distribution of *Earias vittella* (F) on okra with regard to time.

Date of observation	Mean (m)	Variance (S^2)	Dispersion parameter (k)	Variance mean ratio	Mean crowding (m*)	Lloyd's index of patchiness (m*)	Negative binomial		Poisson distribution	
							Goodness of fit		Goondness of fit	
20–12–85	0.65	1.21	0.76	0.85	1.51	2.30	0.39	2.837	0.25–0.10 (3)	12.094	<0.005 (2)
27–12–85	0.93	1.23	0.92	1.31	1.25	1.34	0.82	6.764	0.10–0.05 (3)	9.942	0.02–0.01 (3)
3–1–85	0.88	1.56	1.17	1.75	1.64	1.35	0.64	1.653	0.50–0.25 (3)	9.681	0.02–0.01 (3)
10–1–86	1.83	3.71	1.78	2.02	2.85	1.55	1.50	3.789	0.75–0.50 (5)	25.865	<0.005 (4)
17–1–86	1.54	2.31	3.08	1.50	2.04	1.32	1.37	1.431	0.90–0.75 (4)	13.880	<0.005 (4)
24–1–86	1.65	2.96	2.08	1.79	2.44	1.47	1.39	5.867	0.50–0.25 (5)	7.585	0.25–0.10 (4)
31–1–86	2.31	3.31	5.30	1.43	2.74	1.18	2.16	1.869	0.95–0.90 (6)	5.377	0.50–0.37 (5)

Figures in parentheses are degrees of freedom.

The values of Lloyd's index of mean crowding (m*) were also higher than mean density (m) values, therefore, Loyd's index of patchiness was larger than unity in all the cases confirming the finding that the egg population was overdispersed.

The value of χ^2 and probability of fit for negative binomial distribution shown in Table 1 indicated good degree of agreement between observed and expected frequencies except on 31–1–1986 where Poisson distribution also fitted more closely. The possible reason for this could be sampling error.

The mean size of clump (λ) was less than two in most cases except on 31–1–1984 indicating that aggregation was due to environment heterogeneity. If λ (ARBOUS & KERRICH, 1951; RICHARDS & WALOFF, 1961) is less than two, it is observed that distribution is due to environmental heterogeneity. While values greater than two indicate that both environmental and insect behaviour are working together. The distribution of eggs on 31–1–1984 could be due to egg laying by a brood of adults emerged just then.

The data on within the field distribution of *E. vittella* eggs are presented in Table 2. The mean number of eggs laid were more in the outer quadrats as compared to inner quadrats. The values of variances observed were more than the means indicating that eggs were distributed contagiously. Lloyd's index of patchiness was greater than unity, confirming the contagious distribution. The χ^2 values and probability of fit indicated good agreement between observed and expected frequencies for negative binomial.

Vertical distribution : The results on the distribution of *E. vittella* eggs in relation to plant height are presented in Table 3. The perusal of data indicated that more eggs were

TABLE 2. Statistical parameters for distribution of eggs of *Earias vittella* F. within the field.

Sampling unit	Mean (m)	Variance (S^2)	Dispersion parameter (k)	Variance mean ratio	Mean crowding (m^*)	Lloyd's index of patchiness $(m^*)/(m)$	λ	Negative Binomial		Poisson distribution	
								Goodness of fit		Goodness of fit	
								χ^2		χ^2	
Outer quardrat	1.75	2.75	3.04	1.57	2.32	1.32	1.56	0.259	0.995–0.990 (4)	3.470	0.50–0.25 (3)
Middle quadrat	1.47	2.05	3.77	1.39	1.86	1.26	1.34	4.535	0.25–0.10 (3)	9.678	0.025–0.10 (3)
Inner quadrat	1.45	2.10	3.23	1.44	1.89	1.30	1.30	0.422	0.95–0.90 (3)	3.298	0.50–0.25 (3)

Figures in parentheses are degrees of freedom.

TABLE 3. Vertical distribution of eggs of *Earias vittella* F. within okra plant.

Sampling unit	Mean (m)	Variance (S^2)	Dispersion paramter (k)	Variance mean ratio	Mean crowding (m^*)	Lloyd's index of patchiness $(m^*)/(m)$	Negative binomial		Poisson distribution	
							χ^2	Goodness of fit	χ^2	Goodness of fit
Upper half										
Buds	1.11	1.33	5.49	1.20	1.31	1.18	0.436	0.095–0.75 (3)	0.610	0.75–0.50 (3)
Fruits	0.30	0.39	0.97	1.30	0.60	2.02	0.032	0.90–0.75 (1)	0.0633	0.50–0.25 (1)
Lower half										
Buds	0.24	0.25	6.13	1.03	0.28	1.16	2.02	0.25–0.10 (1)	—	0.05–0.025 (1)
Fruits	0.45	0.70	0.34	1.53	0.99	2.17	0.304	0.75–0.50 (2)	—	0.05–0.025 (2)

Figures in parentheses are degrees of freedom.

deposited on the upper half part of the plant as compared to the lower region. Also, the mean number of eggs deposited were more on buds in the upper portion and on fruits in the lower portion and vice-versa. Investigations in Ludhiana (India) on *Earias* on cotton revealed that females placed maximum eggs at top (41–50 cm) plant canopy. (CHAKRAVARTHY, 1985). Again the egg count fitted to negative binomial as well as Poisson but the fit of negative binomial was much closer to the observed values. This indicated that eggs were randomly distributed with the tendency towards aggregation.

Since the egg count both in respect of field quadrats and in different portions of the plant showed over-dispersion, Iwao's regression equation between mean crowding and mean as well as Taylor's power law which gives a relation between variance and mean were computed.

The Iwao's patchiness regression was

$$m^* = 0.3615 + 1.1384\ m \quad \text{— (i)}$$

The Taylor Power Law obtained was

$$S^2 = \text{antilog}\ 0.4030\ m^{1.1168} \quad \text{— (ii)}$$

The values of index of basic contagion ($\alpha = 0.3615$) being near to zero indicated that eggs were distributed singly (one egg per colony) but the colonies were aggregated as the value of coefficient of Density contagiousness was greater than unity ($\beta = 1.1384$). The coefficient of dispersion in Taylor's Power Law (equation ii) being greater than one (1.1168) is an indication of aggregation pattern of shoot and fruit borer eggs.

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POPULATION DENSITY IN DIFFERENT PARTS OF THE MOUND NESTS OF THE TERMITE, *ODONTOTERMES OBESUS* (RAMBUR) AND THEIR FUNCTIONAL BEHAVIOUR

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Population density of major and minor workers, soldiers and nymphs from the different parts of the mound nest and their functional behaviour were studied. The population density of major workers in the peripheral region of the fungus garden in damaged parts under repair was found high ($P<001$) compared to other regions of the mound. The minor worker population in the royal chamber was more ($P<001$) than in peripheral fungus garden and in damaged parts under repair. Large number of soldiers were recorded in the royal chamber and in the damaged parts under repair ($P<001$). Nymphs were concentrated more in the fungus garden around the royal chamber.

(*Key words*: population density, *Odontotermes obesus*, royal chamber, damaged parts, fungs garden)

INTRODUCTION

Total population and relative percentages of various castes have been studied in *Eutermes exitiosus* (HOLDAWAY *et al.*, 1935), *Coptotermes lacteus* (GAY & GREAVES, 1940), *Odontotermes redemanni* (MUKERJEE & MITRA, 1949), *O. obesus* (GUPTA, 1953), *Microcerotermes beesoni* (SEN-SARMA & MISHRA, 1969; MALISSE *et al.*, 1975), *O. microdentatus*, *O. obesus* (AGARWAL, 1976). Distribution of various castes in different parts of the mound of *O. wallonensis* has been studied (VEERANNA & BASALINGAPPA, 1984). The individual behaviour in a colony is often correlated with specific morphological or physiological characteristics which are often emphasized on the individuals within a caste (BLUM, 1977). The present study was undertaken to determine the population density of various castes in different parts of the mound nests and their functional behaviour in *Odontotermes obesus* in the South Indian state of Karnataka.

MATERIALS AND METHODS

The royal chamber, fungus garden of peripheral region and around the royal chamber, and termites in damaged parts under repair, were collected separately in polythene bags from ten natural mound colonies of the termite, *O. obesus*. The population of termites in the royal chamber and in damaged parts under repair were determined by 'whole count' method. Three samples of 100 g/unit of fungus garden in each were taken. The data were analysed statistically using 'T' test, the *P* value less than 0.05 is statistically significant.

RESULTS AND DISCUSSION

Population density of major and minor workers, soldiers and nymphs from the diffrent parts of the mound nest of *O. obesus* is shown in Fig. 1.

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In *Macrotermes subhyalinus*, the population density in the peripheral fungus garden consisted of mainly workers, with minor workers slightly outnumbering the major workers. In the trunk galleries, the major workers population was more (70%) than the minor workers and soldiers (DARLINGTON, 1977). In the present study, the population density of major workers in the peripheral region of the fungus garden and in damaged parts under repair was found high ($P<0.001$) compared to the other regions of the mound. High population of major workers in those regions might be due to the necessity for large number of workers to be involved in construction work of the mound. Population density of minor worker was more in the royal chamber and fungus garden around the royal chamber ($P<0.001$) than other regions of the mound. This might be due to need for feeding of the young nymphs and royal couple and for transfer of the eggs laid by the queen in the royal chamber to the fungus garden for incubation by these specialists as reported in *O. wallonensis* (VEERANNA & BASALINGAPPA, 1984). It was found that most of the eggs laid by the queen were in the fungus garden around royal chamber. Because of this reason, the population of nymphs was highest in the fungus garden around the royal chamber. High population density of soldiers of this species in the royal chamber and in the damaged parts under repair might be for guarding the royal couple and major workers while foraging and constructing the mound as in *O. wallonensis* (VEERANNA & BASALINGAPPA, 1984). It is evident from the above results that the population of various castes in different parts of the mound may be dependent on their functional behaviour and on the need for the overall efficiency of the social system of this termite.

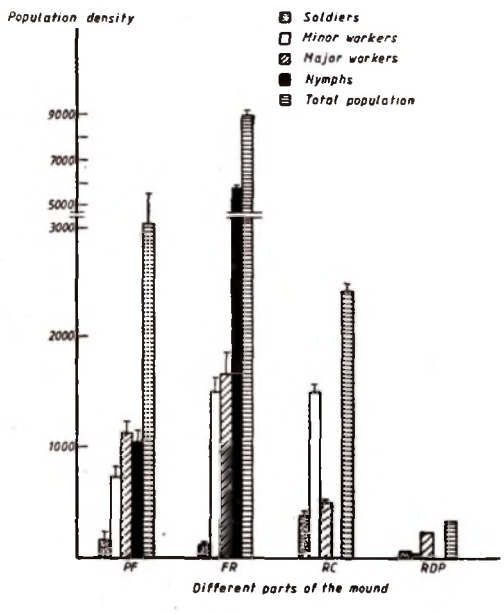

Fig. 1. Population of various castes of the termite, *O. obesus* in different parts of the mound, viz. peripheral fungus garden (P.F.), fungus garden around the royal chamber (F.R.), royal chamber (R.C.) and in damaged parts under repair (R.D.P.)

ACKNOWLEDGEMENTS

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BIOLOGY OF A LEAF SCALE INSECT, *GREENASPIS DECURVATA* GREEN (HOMOPTERA : DIASPIDIDAE) IN SUGARCANE

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Greenaspis decurvata **Green (Homoptera: Diaspididae), earlier recorded from lemon grass in Kerala was for the first time collected from sugarcane leaves in Madurai district, Tamil Nadu. Details of its life history studied on potted plants at Coimbatore are given in this paper. Males completed their life cycle in 24 days while females take about 38 days. The sex ratio of females: males is about 1 : 1 in nature, while it is 1 : 0.94 as studied in potted plant conditions.**

(*Key words*: *Greenaspis decurvata*, biology, sugarcane)

INTRODUCTION

Several species of scale insects attack different parts of sugarcane, like stem, leaf sheath and leaf lamina. Some of them are very specific in their habitats like *Aulacaspis madiunensis* (Zehntner) attacking only stem and *Ceroplastes actiniformis* Green and *Pulvinaria sacchari* de Lotto infesting only leaves (RAO & SANKARAN, 1969). These minor pests may become economically important pests as observed in *Melanaspis glomerata* (Green), which in recent years has assumed major pest status and spread through some of the susceptible varieties like 'Co 740' in Andhra Pradesh and other states. ASARI *et al.* (1977) reported *Greenaspis* (= *Duplalchionaspis*) *divergens* Green infesting lemon grass in Kerala. Recently a related species, *Greenaspis decurvata* (Zehrtner) was found infesting the leaves of sugarcane in Madurai district of Tamil Nadu on sugarcane variety 'Co 419'. Infestation was noticed during the first week of January 1984. This species occurs specifically on leaf lamina where there is heavy population and prolific crawler emergence. Exceptionally, under high population level very few individuals occur in leaf sheath just below the collar region.

Symptoms of damage:

The entire leaf lamina on the upper surface is fully covered by both sexes of the insect and partly on the lower surface. The most conspicuous sign of feeding is the appearance of irregular yellowish spots and upon continuous feeding these spots coalesce and drying starts from the tip of the leaf lamina and later the entire leaf dries up.

MATERIALS AND METHODS

The infested leaves with adequate adult females were cut into pieces of 12 to 18 cm size and fixed on one of the leaves of a potted sugarcane plant ('Co 6304') and then the plant covered with wiremesh cage (80 × 27.5 cm, with mesh100/sq cm) so as to avoid predation and parasitization by natural enemies. Crawlers which settled on the fresh leaves were reared till they became adults. From this culture, leaf bits of adequate size with known number of adult females were cut and fixed onto another protected potted plant of variety 'Co 6304' (20 cm dia × 75 cm height). The crawlers emerged at a particular time was observed for settlement and marked with marking pen. Details of development were recorded by observing the enlargement of

scale coating and further moulting of both sexes. Several settlers of the same age group were marked as reference population. Diffrent instars were recorded by observing the secretion of waxy coating over the soft body of scale insect. In males, pre-pupal and pupal stages were ascertained by dissecting developing male from the reference culture daily. The pre-oviposition period of female was calculated by observing the duration between the cessation of expansion of waxy coat of the third instar and the beginning of oviposition. Oviposition period was assessed by removing the eggs laid by females by slightly lifting the armour a little and observing the duration by successive observations. Fecundity was estimated by counting the number of egg shells and eggs still present in the ovaries of about 20 randomly collected females. The incubation period was studied by removing the eggs beneath the armour of actively ovipositing females and removing the eggs to a glass Petridish embedded with filter paper provided with wet sponge at the bottom and observing for hatching of crawlers.

RESULTS

Males emerge in large numbers and mate with the developed and receptive females which are present on the leaf lamina.

Eggs are laid one by one with the aid of pygidial plates and lobes. Before commencement of egg laying, the female occupies the greater part of the space under the armour. When once the female starts egg laying, the body slowly begins to shrink, ultimately occupying only a small part of anterior end of the armour. A female lays 29 to 63 eggs (mean $=42.65 \pm 12.27$) during its life span. The duration of oviposition lasts for 7 to 9 days (mean $=7.29 \pm 0.49$) (Fig. 1).

Egg:

The freshly laid eggs are shiny pink in colour and more or less oval in shape. There

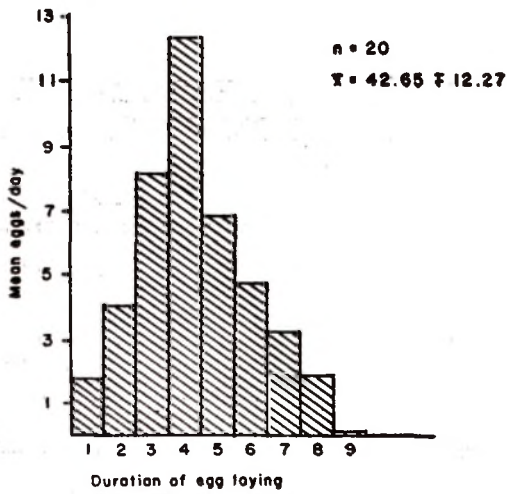

Fig. 1. Frequency distribution of number of eggs of *Greenaspis decurvata*.

is no marked colour change before hatching. The crawlers hatch out through the terminal end by splitting the chorion and the empty egg shells are accumulated under the armour. The egg measures 0.59 mm in length and 0.20 mm in width. The frequency distribution of egg laying is illustated in Fig. 1.

Crawlers:

The first instar nymphs of the scale insect has two phases; a motile phase (crawlers) and a sedentary phase (settlers). The crawlers emerge from under the armour through the raised posterior pygidial end. It has six well developed legs as well as two normal antennae. The crawlers move around for few hours i.e., 2 to 6 hours and then settle down by inserting its stylets in the leaf tissue.

Settlers (Fig. 2):

The crawlers that have inserted their stylets successfully into leaf tissues and start feeding are called settlers. Since they do not secrete any armour, sex differentiation is not possible at this stage. It measures about 0.33 mm in length and 0.13 mm in width.

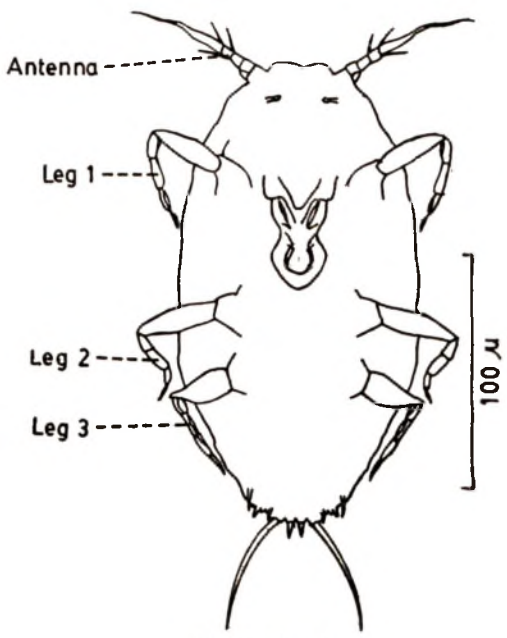

Fig. 2. First instar.

Male:

Second instar (Fig. 3):

The settler moults into second instar and at this stage only, the sexes are discernible. The male body is elongate, while it is globular in female. The settlers secrete a thick cottony white armour lengthwise, which is rectangular and parallel on both sides. This is the second instar. At this stage, the soft bodied scale insect measures about 0.54 mm and 0.30 mm in length and width respectively and passes to third instar called prepupa.

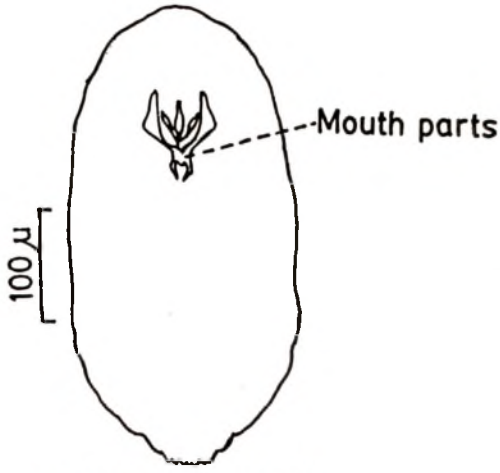

Fig. 3. Second instar (male)

Third instar (Prepupa) (Fig. 4):

This stage is easily recognisable with the rudimentary wing bud. The armour is almost rectangular with parallel sides Prepupal stage measures about 0.54 mm in length and 0.28 mm in width.

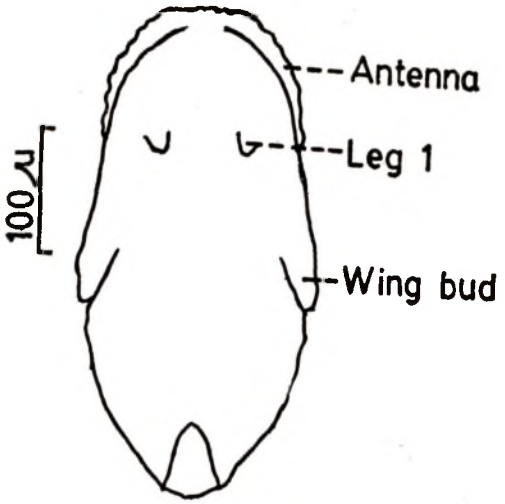

Fig. 4. Prepupa (male).

Fourth instar (*Pupa*) (Fig. 5):

The pupa which is yellowish changes reddish in colour later. Wing bud becomes elongated and a conical stylus develop at the terminal part of the abdomen. Pupa measures 0.60 mm in length and 0.25 mm in width.

Adult male (Fig. 6).

The small gnat–like adult male is reddish at the abdomen, having one pair of glossy white forewings with reduced venation. The hind–wings are represented by a pair

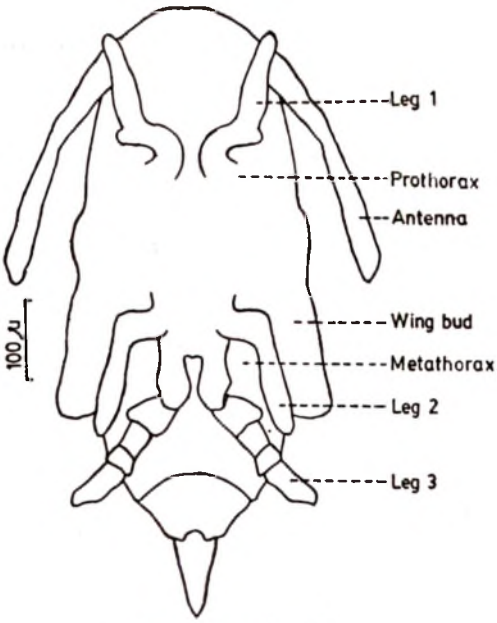

Fig. 5. Pupa (male).

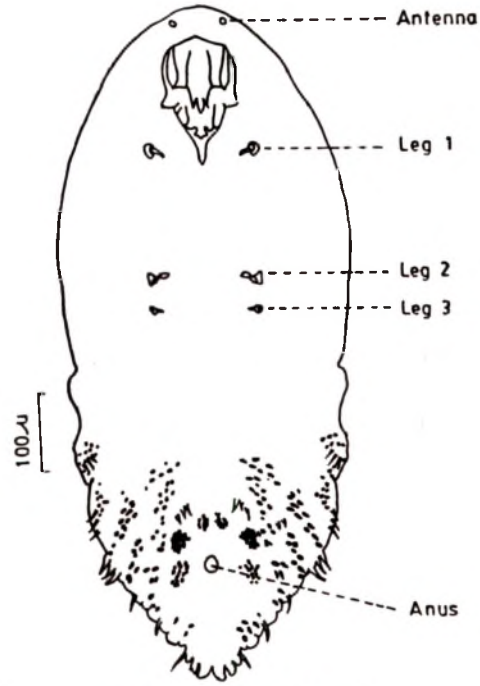

Fig. 7. Second instar (female).

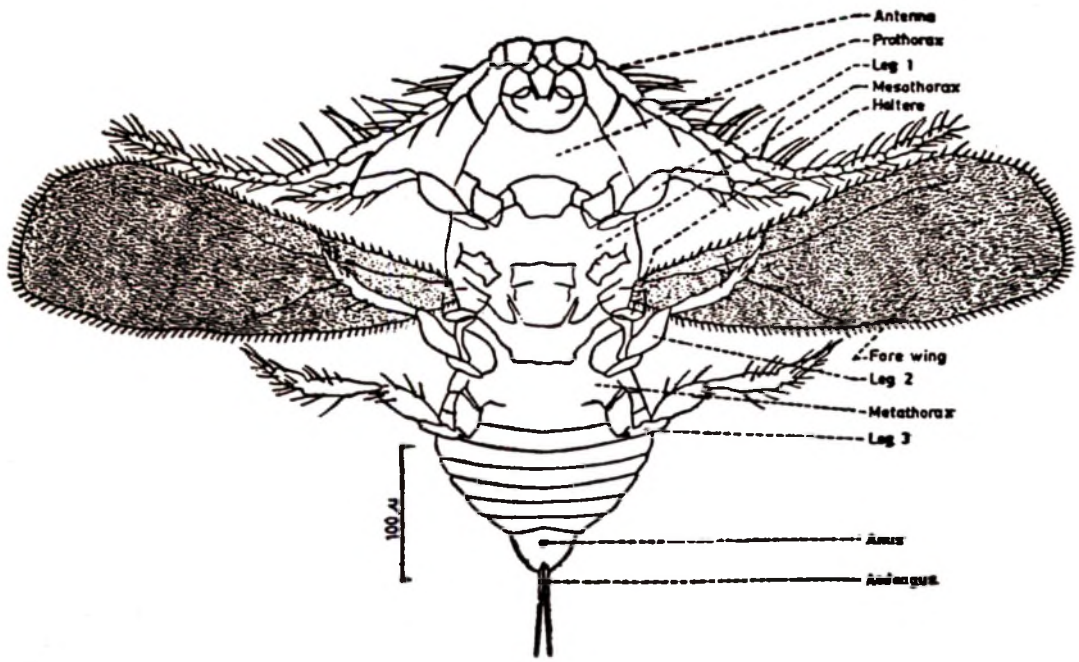

Fig. 6. Adult (male).

of halteres. The antennae of males are well developed, 8 segmented, filiform and equal to that of the wing length (0.59 mm). The body measures about 0.79 mm in length and 0.25 mm in width. The length of the foreleg measures shorter (0.25 mm) than that of middle and hind legs which are equal in length (0.39 mm). A long stylus or male genital sheath is present, at the end of the abdomen. Since mouth parts are nonfunctional, adults do not feed. Their function is to fertilise the females. Adults live for about 1–3 days (mean 2.07±0.80). Males eventually after mating due to senility (Fig. 6).

Female:

Second instar (Fig. 7):

From the posterior side of the settler a thin membranous light brownish waxy coat is secreted posteriorly. It measures 0.78 mm in length which is approximately 2 1/2 times longer and 3 1/2 times wider (0.47 mm) than the first instar.

Third instar (Fig. 8):

After the second instar, a thin white cottony mebranous covering starts extending posteriorly inside which the yellowish soft bodied insect feeds for about 17 to 18 days (mean 17.44 ± 0.51). Third instar is double the size of the 2nd instar and about 5 times larger than the first instar. This measures 1.48 mm in length and 0.72 mm in width.

Adult female (Fig. 8).

The yellowish female lies under the thick protective armour. There is a raised position of armour at the posterior side and this allows for easy accession of males to femaales (Fig. 8).

Population and sex ratio:

The mean population of the scale insect was 1262, 1491, and 1536 during January 1984 in the 1st, 3rd and 5th leaves from top,

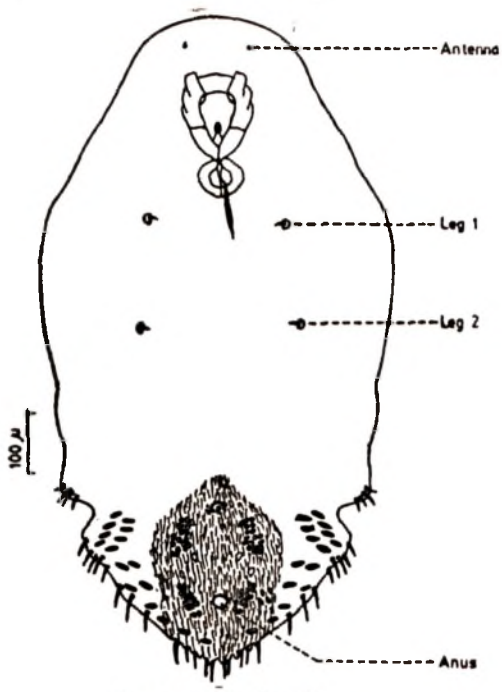

Fig. 8. Adult (female).

TABLE 1. *Biology of G. decurvata.*

Stages	Duration
Egg (h)	19
1st instar (days)	6.44±0.51
2nd instar (days)	
Male	10.99±0.75
Female	4
3rd instar female (days)	17.44±0.51
Preoviposition (days)	4.06±0.24
Oviposition (days)	7.29±0.49
Male prepupal (days)	2.19±0.54
Male pupal (days)	4.19±0.19
Audlt male longevity	2.07±0.80

which showed slight variation in ratio of 1:1.1, 1:1.03 and 1:0.80 for females: males. The mean sex ratio was 1:0.94. The duration of different stages is given in Table 1 and the stages of the scale insect are illustrated in Figures 2 to 8.

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STUDIES ON "SKIP ROW COVERAGE" AGAINST BOLLWORM DAMAGE AND PARASITE EMERGENCE IN COTTON

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Studies were made to assess the effectiveness of insecticide application by skip row coverage (SRC) viz., alternate row (ARC), alternate pair row (APRC) and alternate period alternate row coverage (APARC) methods in comparison with full coverage (FC) against bolloworm damage and the parasite emergence in cotton. Skip row coverage with deltamethrin as alternate row and alternate period alternate row was as effective as that of full coverage in reducing boll and loculi damage. There was also no significant reduction of yield under skip row coverage treatments as compared with full coverage. Carbaryl, endosulfan and monocrotophos (as both coverage methods) were not as effective as deltamethrin skip row coverage. Cabaryl as skip row coverage (ARC and APARC) enabled more number of parasite, *Apanteles angaleti* Muesb. emergence as compared with full coverage.

(*Key words*: skip row coverage, cotton, *Earias vittella*, *Pectinophora gossypiella*, *Apanteles angaleti*)

INTRODUCTION

Regular and repetitive application of insecticides in cotton not only increases the cost of plant protection but also causes a severe ecological imbalance in the cotton ecosystem. As an alternative to the blanket application, restricted treatment has been employed to obtain successful control of insect pests of citrus, corn and tobaoco (DEBACH & LANDI, 1959; ANDERSON & REYNOLDS, 1960; LAWSON *et al.*, 1961). As information on restricted treatment in cotton is scanty, studies were made to find out the effectiveness of "skip row coverage" (SRC) viz., application of insecticides in alternate row (ARC), alternate pair row (APRC) and alternate period alternate row coverage (APARC) methods in comparison with treatment of all rows i.e., full coverage (FC), against bollworms and their natural enemies in cotton.

MATERIALS AND METHODS

Field experiments were conducted during winter cotton season of 1981–1982 and 1982–1983 in randomized block design with three replications for each treatment (Tables 1 and 2). The variety used was 'MCU.5 VT' (*Verticillium* tolerant). The agronomic practices recommended for the variety were followed. Six rounds of treatments were given on 49, 67, 82, 106, 124 and 141 days after sowing (DAS) in the first experiment and on 49, 64, 83, 104, 121 and 145 DAS in the second experiment. All the shed fruiting parts from the central two rows of each plot were collected, sorted out into infested and uninfested ones and the damage was expressed as percent to the total shed fruiting parts. The loculi attack due to bollworms was assessed from 25 green bolls randomly selected. Loculi damage in opened bolls was assessed from 10 randomly selected plants in the case of full coverage (FC) treatments. In respect of ARC (alternate row coverage), ARPC (alternate pair row coverage) and APARC (alternate period alternate row coverage) treatments, two sets of five plants each were selected at random, one set from treated rows and another set from untreated rows and the mean of the ten plants of the two sets was considered for the particular treatment. Bad and stained kapas due to bolloworm damage and the yield per plot (good seed

cotton) were estimated at harvest. At each picking, 100 to 200 g of bad kapas damaged by bollworms was collected from each plot and observed for the emergence of *Apanteles angaleti* Muesb. and *Pectinophora gossypiella* Saunders.

RESULTS AND DISCUSSION

Loculi damage in the sampled green bolls revealed that skip row coverage with deltamethrin as APRC was as effective as that of FC with the same insecticide, while carbaryl. endosulfan and monocrotophos as skip row coverage were not affective against the bollworms (*E. vittella* and *P. gossypiella*). Deltamethrin as ARC as well as FC was effective in reducing loculi damage on opened bolls at harvest. Monocrotophos, endosulfan and carbaryl as skip row coverage methods were not effective in this regard (Table 1).

TABLE 1. Effect of skip row coverage of insecticides on bollworm damage, parastite emergence and yiled (Rabi 1981–1982).

Treatment		dosage g ai/ha	Loculi damage in green bolls% (139 DAS)	Loculi damage at harvest %	Bad and stained kapas%	Seed cotton yield kg/ha	Parasite/host emergence from bad kapas	
							A angaleti	*P. gosypiella*
monocrotophos	FC	500	20.9 (26.9)	33.4 (35.2)	30.2 (33.3)	1466	3.3	7.3
monocrotophos	ARC	250	25.5 (30.0)	33.9 (35.5)	25.6 (30.4)	1582	4.3	5.3
monocrotophos	APRC	250	26.2 (30.6)	36.0 (37.5)	23.0 (28.5)	1349	3.3	11.0
endosulfan	FC	700	26.0 (30.4)	25.3 (33.9)	16.9 (23.5)	2464	4.7	6.3
endosulfan	ARC	350	19.9 (26.6)	22.8 (28.9)	16.6 (24.1)	1985	4.0	3.7
endosulfan	APRC	350	27.1 (31.3)	21.2 (27.3)	14.8 (22.2)	2155	4.0	2.3
carbaryl	FC	1000	14.7 (22.4)	16.2 (23.8)	11.5 (19.8)	2105	0.7	1.3
carbaryl	ARC	500	20.6 (27.0)	31.0 (33.8)	16.6 (23.9)	2096	1.7	3.3
carbaryl	APRC	500	23.9 (28.6)	24.0 (29.3)	13.8 (21.6)	1852	1.3	3.7
deltamethrin	FC	15	9.1 (16.3)	5.0 (12.7)	2.2 (8.5)	2970	0.0	0.3
deltamethrin	ARC	7.5	18.2 (23.8)	7.5 (18.9)	3.9 (11.3)	2923	0.0	0.3
deltamethrin	APRC	7.5	10.1 (18.3)	9.0 (17.4)	4.5 (12.3)	2566	0.0	1.7
untreated		..	28.2 (31.9)	33.7 (35.4)	27.7 (31.5)	1108	4.0	13.0
CD ($P=0.05$)			8.86	4.57	6.22	352	..	..

Figures in parentneses are arc sine $\sqrt{\text{percentage}}$ values. DAS — dayt after sowing; FC — full coverage, ARC and APRC are altrnate row and alternate pair row coverage respectively.

In respect of reducing bad and stained kapas due to bollworm damage, the skip row coverage treatments with deltamethrin as ARC and APRC were as effective as full coverage treatment and also superior to full coverage and other treatments with monocrotophos, endosulfan and carbaryl (Table 1).

Deltamethrin as full coverage was the only treatment which gave effective reduction of shed fruiting parts damage and bad kapas due to bollworms (Table 2). The skip row coverage methods with deltamethrin were next in order, while endosulfan and carbaryl (both as full and skip row coverage) were not effective. The skip row coverage with deltamethrin was as effective as full coverage with deltamethrin in respect of reducing boll and loculi damage (Table 2).

The effectiveness of deltamethrin against bollworm damage has been reported by several workers (BHAMBURKAR & KATHANE,

TABLE 2. Effect of skip row coverage of insecticides on bollworm damage parasite emergence and yield (Rabi 1982-1983).

Treatment		doasage g ai/ha	Per cent infestation in shed fruiting parts DAS 170	Per cent attack in bolls — DAS 150	Loculi damage %	Bad and strained kapas %	Seed cotton yield kg/ha	Parasite/host emergence from bad kapas	
								A. angaleti	*P. gossypiella*
endosulfan	FC	700	41.6 (40.15)*	12.1 (20.40)*	33.4 (35.31)*	25.7 (30.48)*	1809	9.67 (3.18)+	3.33 (1.93)+
endosulfan	ARC	350	28.2 (32.05)	9.7 (18.15)	34.2 (35.79)	26.8 (31.20)	1663	14.67 (3.76)	6.67 (2.65)
endosulfan	APARC	350	30.0 (33.27)	15.3 (23.01)	37.2 (37.59)	28.2 (32.09)	1843	25.33 (5.02)	8.00 (2.89)
carbaryl	FC	1000	35.8 (36.76)	20.3 (26.76)	28.0 (31.94)	28.0 (31.92)	1841	13.67 (3.51)	5.00 (2.23)
carbaryl	ARC	500	46.9 (43.20)	12.1 (20.39)	37.5 (37.75)	34.7 (36.09)	1622	48.00 (6.80)	27.00 (5.02)
carbaryl	APARC	500	33.7 (35.48)	13.3 (21.40)	33.9 (35.59)	30.3 (33.40)	1632	35.67 (5.77)	13.67 (3.60)
deltamethrin	FC	15	9.5 (17.93)	4.5 (12.29)	7.2 (15.53)	3.5 (10.70)	3022	4.00 (2.09)	3.33 (1.90)
deltamethrin	ARC	75	20.3 (26.75)	5.1 (13.08)	11.7 (19.99)	8.5 (16.94)	2607	3.67 (2.02)	2.00 (1.48)
deltamethrin	APARC	7.5	21.7 (27.77)	5.4 (13.35)	10.5 (18.88)	6.9 (15.19)	2691	4.00 (1.84)	2.67 (1.64)
untreated	..	..	30.8 (33.71)	18.3 (25.31)	47.5 (43.58)	31.6 (34.22)	1239	24.33 (4.78)	11.67 (3.37)
CD ($P=0.05$)		..	8.08	5.79	8.33	4.19	448	2.18	1.54

*, = Figures in parentheses are arc sine $\sqrt{\text{percentage}}$ and $\sqrt{X}$ values respectively.
DAS—day after sowing; FC—full-overage, ARC and APARC are alternate row and alternate period alternate row coverage respectively.

1984; PAWAR *et al.*, 1984). However, from the present study it was observed that skip row coverage treatment with deltamethrin was as effective as that of full coverage with the same insecticide against reduction of bollworm damage. ELLIOT *et al.* (1973) and RUSCOE (1977) illustrated that the fresh deposits of pyrethroid insecticidal sprayings exhibit adulticidal and ovicidal effects for 24–28 h. Later on, they act as larvicides for next few days, and thereafter exert an antifeedant and repellant influence. As a result of cumulative effect of these actions, deltamathrin (Pyrethroid) applied as skip row coverage treatment (ARC and APRC) was as effective as that of full coverage (FC) treatment. Further, it was presumed that the spray drift-particles fallen on the unsprayed rows might have also contributed for the effectiveness to some extent.

There was no significant reduction of yield between the skip row coverage treatments (ARC and APRC) and full coverage treatment with deltamethrin. The skip row coverage treatments were also superior to full coverage treatment with monocrotophos, endosulfan and carbaryl in registering higher yield. As discussed earlier, the superior efficacy exhibited by skip row coverage treatments with deltamethrin over monocrotophos, carbaryl and endosulfan (as full and skip row coverage treatment) resulted in higher seed cotton yield and less and stained kapas, as compared with other treatments (Tables 1, 2).

Successful control of purple scale, *Lepidosaphes beckii* (Newman) on citrus was achieved by adopting treatment of alternate pairs of tree rows at 6 month intervals with a non-selective oil treatment (DE BACH & LANDI, 1959). The present study has shown that foliar spray of deltamethrin, a non-selective, broad spectrum pyrethroid insecticide as alternate row (ARC) and alternate period alternate row coverage (APARC) has been found to be equally effective as full coverage (FC) against bollworm damage and increasing the yield.

Parasite and host activity:

Larval parasite, *A. angaleti* emergence from the bad kapas obtained from deltamethrin treatment (as all methods-FC, ARC and APARC) was the least as comapared to all other treatments including check. Correspondingly, the host, *P. gossypiella* emergence from bad kapas obtained from the same treatment was also the least (Table 2). HOUSE *et al.* (1985) have shown that synthetic pyrethroids depressed predator and parasite population, but did not entirely exclude them from cotton. In the present study also, synthetic pyrethroid, deltamethrin, under different methods of application depressed the parasite population. The depression of the parasite population may also be due to lower population level of the host insect, as a result of efficient control of it, as compared with other treatments viz., endosulfan and carbaryl. Carbaryl as skip row coverge treatment (ARC and APARC) enabled more parasite emergence as compared to full coverage (FC) treatment with the same insecticide. Thus, skip row coverage treatment with carbaryl showed selectively against the parasite *A. angaleti*.

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ROLE OF RHIZOME MAGGOT *MIMEGRALLA COERULEIFRONS* MACQUART IN RHIZOME ROT OF GINGER[1]

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Studies were conducted under green house conditions to determine the status of rhizome maggot *Mimegralla coeruleifrons* Macquart (Micropezidae : Diptera) as a pest of ginger (*Zingiber officinale* Rosc.) and its role in rhizome rot disease caused by *Pythium aphanidermatum*. The results proved that *M. coeruleifrons* is not a primary pest of the crop and has no role in the incidence of rihizome rot disease.

(*Key words*: *Mimegralla coeruleifrons*, ginger, *Zingiber officinale*, rhizome rot, rhizome maggots, *Pythium aphanidermatum*)

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is an important spice crop grown in India to an extent of about 5,24,600 ha with a total annual production of about 1,27,000 tonnes (Source: Directorate of Economics and Statistics, Department of Agriculture and Co-operation, Ministry of Agriculture, New Delhi). Seven species of dipteran flies, the maggots of which bore into rhizomes, have been reported by various authors (FLETCHER, 1914; MALLOCH, 1927; NAIR, 1975; ANONYMOUS, 1977; SATHIAMMA, 1979), among which *Mimegralla coeruleifrons* Macquart (Micropezidae : Diptera) is the most common one. The crop is also susceptible to rhizome rot disease caused by *Phythium aphanidermatum*, which is a serious malady. Maggots of *M. coeruleifrons* are generally found associated with rhizome rot-affected ginger.

PREMKUMAR et al. (1982) reported the presence of maggots and *Pythium* spp. in 58 per cent and *Pythium* spp. alone in 42 per cent of ginger samples examined. However, none of the samples had maggots alone. GHORPHADE et al. (1983) reported that infestation by *M. coeruleifrons* was endemic in certain districts of Maharashtra state. However, the damage was less in light and well drained soils. In order to determine the status of rhizome maggots as pests of ginger and their role in the etiology of rhizome rot, trials were conducted at National Research Centre for Spices, Calicut, Kerala under green house conditions and the results are reported here.

MATERIALS AND METHODS

Ginger plants (c.v. 'Maran') were raised in earthen pots of 25 cm diameter filled with 3 kg sterilised soil each. Seed rhizomes of ginger @ 25 g per pot were sown after surface sterilization with 0.1% mercuric chloride. The pots were maintained inside insect proof cages of 1 × 1 × 1 m size under shade at a temperature range of 23.5 ± 1°C (minimum) and 32 ± 1°C (maximum) and at a relative humidity range of 73.1 to 90.8%. The treatments were imposed 60 days after planting the seed rhizomes in pots. The treatments were T1 : releasing adult *M. coeruleifrons*, T2 : inoculation of plants with *P. aphanidermatum* + releasing adult *M. coeruleifrons* and T3 : inoculation with *P. aphanidermatum*. Five potted plants were maintained under each treatment and the experiment was replicated thrice. Adults of *M.*

[1] Contribution No. 94 of National Research Centre for Spices, Calicut–673 012, Kerala, India.

coeruleifrons (30 pairs each) were released on ginger plants under treatments T1 and T2. For inoculation of fungus, a pathogenic isolate of *P. aphanidermatum* was cultured in roux bottles containing 100 ml potato dextrose broth each. After 15 days of incubation at 25 ± 1°C, the fungal mat from each bottle was repeatedly washed and blended using sterile distilled water and 100 ml of mycelial suspension was poured around the pseudostems in each pot in treatments T2 and T3. The occurrence of disease and maggots was recorded periodically and at the end of the experiment. The experiment was conducted for two consecutive years (1985 and 1986).

RESULTS AND DISCUSSION

The symptoms of rhizome rot appeared in all the pots inoculated with *P. aphanidermatum* irrespective of the presence of *M. coeruleifrons*. The ginger plants which were inoculated with *M. coeruleifrons* alone (T1) remained healthy and the rhizomes of these plants did not contain maggots. Nine and twelve plants under treatments with *P. aphanidermatum* + *M. coeruleifrons* (T2) and *P. aphanidermatum* (T3) alone, respectively, took up disease during 1985 and rhizomes of those plants which received *P. aphanidermatum* + *M. coeruleifrons* contained maggots. However, during 1986, all the plants which received *P. aphanidermatum* contracted the disease and the rhizomes of plants treated with *P. aphanidermatum* + *M. coeruleifrons* contained maggots also. The absence of maggots on plants which were inoculated only with adult insects indicated that *M. coeruleifrons* is not a primary pest of ginger and could not infest healthy rhizomes (Table 1).

Maggots of *M. coeruleifrons* were observed in 26.4 per cent of diseased samples collected during the surveys conducted in major ginger growing areas of Kerala, a major ginger producing state in India. The surveys also revealed that healthy samples were free from maggots (KOYA, 1988). Studies on the biology of *M. coeruleifrons* also showed that the maggots were unable to feed on healthy whole rhizomes when supplied as food. Similar observations were also made by RADKE & BORLE (1982) who reported that rotting of rhizomes occurred first and the flies preferred such rhizomes for egg laying.

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Table 1. Role of *Mimegralla coeruleifrons* in rhizome rot of ginger.

Treatments	No. of plants diseased		No. of healthy plants	
	1985	1986	1985	1986
T1 — Release of *M. coeruleifrons* adults	0 (0)	0 (0)	15 (0)	15 (0)
T2 — Inoculation with *P. aphanidermatum* + release of *M. coeruleifrons* adults	9 (7)	15 (15)	6 (0)	0 (0)
T3 — Inoculation with *P. aphanidermatum*	12 (0)	15 (0)	3 (0)	0 (0)

Figures in parentheses are no. of plants with maggots.
No. of pots per treatment = 15.

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REVERSION OF INSECTICIDE RESISTANCE IN *TRIBOLIUM*: FATE OF *p,p'*DDT, LINDANE, MALATHION AND PHOSPHINE RESISTANCE DURING SELECTION FOR PIRIMIPHOS-METHYL RESISTANCE IN *TRIBOLIUM CASTANEUM* (HERBST)

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p, p 'DDT, lindane, and phosphine resistance showed reversion during selection for pirimiphos-methyl resistance in *p, p'*DDT, lindane, and phosphine resistant strains of *Tribolium castaneum*, respectively, whereas malathion resistance did not regress during pirimiphos-methyl selection in malathion resistant strain of *T. castaneum*.

(*Key words*: reversion, resistance, pirimiphos-methyl resistant, *Tribolium castaneum*)

INTRODUCTION

Continuous and widespread usage of DDT, lindane and malathion in storage had resulted in development of resistance in stored grain insect pests throughout the world (CHAMP & DYTE, 1976). This necessitated to develop alternative insecticides for their control. Pirimiphos-methyl was found to be one of the effective replacements from the view point of cost-benefit ratio, bioefficacy and safety (TYLER & BINNS, 1982; GOLOB & MUWALO, 1984). Removal of insecticides from insect control programme often results in reversion of insecticide resistance (KEIDING, 1967; GEORGHIOU, 1972). Therefore present investigation was undertaken to ascertain the fate of *p,p'*DDT, lindane, malathion and phosphine resistance consequent upon selection of resistance to pirimiphos-methyl in laboratory selected strains of *Tribolium castaneum*.

MATERIALS AND METHODS

Development of resistance to pirimiphos-methyll was carried out in *p,p'*DDT (BHATIA & PRADHAN, 1968), lindane (BHATIA & PRADHAN, 1971), malathion (PASALU, 1974) and phosphine (SAXENA & BHATIA, 1980) resistant strains of *T. castaneum* (AHUJA, 1989). The *p,p'*DDT resistant (DR), the lindane resistant (LR), the malathion resistant (MR), and the phosphine resistant (PR) strains were in 60th, 69th, 40th and 27th generation of selection, respectively, when selection for resistance to pirimiphos-methyl was initiated. The DR, the LR, and the MR strains were exposed to pirimiphos-methyl for 9 generations whereas the PR strain was exposed for 6 generations and consequent upon selection were designated as the DR–PMR, the LR–PMR, the MR–PMR, and the PR–PMR respectively. During selection, treatment with the insecticides to which they were originally selected was withdrawn. Simultaneously, a colony of the DR, the LR, the MR and the PR strains was maintained without selection pressure of any insecticides and these strains were designated as the DR–U, the LR–U, the MR–U and the PR–U, respectively.

The toxicity of *p,p'*DDT, lindane and malathion to the adults (8–10 days old) of the in-

secticide resistant and the susceptible strains was tested using direct spray method of bioassay (BHATIA & PRADHAN, 1968). The toxicity of phosphine to the adults of the resistant and the susceptible strains was determined according to the method given by SAXENA & BHATIA (1980). The data so obtained were subjected to probit analysis (FINNEY, 1971). The reversion in resistance was worked out by comparing the LC_{50} values of the resistant strains before and after selection with pirimiphos-methyl to that of the susceptible strain. The method of selection for resistance to pirimiphos-methyl bioassay, and maintenance of culture of various strains had been detailed out elsewhere (AHUJA, 1989).

RESULTS AND DISCUSSION

The data presented in Table 1 showed that the removal of selection pressure of *p,p'*DDT, lindane, malathion and phosphine in the respective resistant strains of *T. castaneum* had resulted in reversion of resistance to these insecticides in spite of development of high level of pirimiphos-methyl resistance in the DR–PMR (31.72), the LR–PMR (21.91), the MR–PMR (13.91) and PR–PMR (7.91) strains (AHUJA, 1989). However, the reversion of *p,p'*DDT, and lindane resistance was comparatively of low order in the pirimiphos-methyl selected strains (DR-PMR, LR-PMR) than in the non selected strains (DR–U, LR–U). Similar level of reversion in phosphine

TABLE 1. Toxicity data of *p, p'*DDT, lindane, malathion and phosphine to the adults of the respective insecticide resistant strains of *T. castaneum*.

Strain	Insecticide	Number of generations of release of selection pressure	Heterogeneity D.F.	Heterogeneity X^2	Regression co-efficient b ± SE	LC_{50} (%)	Fiducial limit	Resistant ratio (R/S)
Susceptible(S)	*p,p'*DDT	—	4	5.7737	2.0228±0.18	0.0300	0.0260–0.0345	—
DR	,,	—	4	4.6331	1.5583±0.40	2.3580	1.9943–2.7881	78.60
DR–PMR	,,	9	4	6.0256	1.5698±0.18	1.6145	1.3664–1.9076	53.82
DR–U	,,	9	3	0.8908	1.4932±0.17	0.7236	0.5944–0.8809	24.12
S	lindane	—	4	8.7699	2.3319±0.22	0.0938	0.0833–0.1056	—
LR	,,	—	4	2.9132	2.6399±0.29	4.7194	4.1973–5.3063	50.31
LR–PMR	,,	9	4	14.5485*	2.5870±0.26	3.5542	3.2076–3.9383	37.89
LR–U	,,	9	4	15.9696*	3.8180±0.29	2.4442	2.2518–2.6530	26.06
S	malathion	—	4	1.9569	5.6571±0.47	0.0057	0.0050—0.0064	—
MR	,,		4	8.0210	5.2312±0.59	0.1601	0.1521–0.1686	28.59
MR–PMR	,,	9	3	1.0591	4.0112±0.40	0.1554	0.1436–0.1682	27.75
MR–U	,,	9	3	0.3946	6.9122±0.83	0.0792	0.0760–0.0824	14.14
S	phosphine**	—	3	1.8089	2.9668±0.39	0.0481	0.0420–0.0525	—
PR	,,		3	2.5039	4.4930±0.60	0.2650	0.2481–0.2830	05.51
PR–PMR	,,	6	3	2.6837	4.6772±0.43	0.1448	0.1346–0.1559	03.01
PR–U	,,	6	4	8.1045	7.3011±0.64	0.1279	0.1228–0.1333	02.66

*Heterogeneous at P 0.05 and fiducial limits were widened accordingly. **Concentration expressed is mg/l.

resistance was obtained in both the pirimiphos-methyl selected (PR-PMR) and the non-selected (PR–U) strains. In case of malathion resistance, no reversion was obtained in the pirimiphos-methyl selected strain (MR–PMR), whereas considerable reversion was obtained in the non selected strain (MR–U).

No or low level of reversion in resistance during selection with pirimiphos–methyl may be attributed due to the cross-resistance resulted from the development of resistance to pirimiphos–methyl. AHUJA (1986) reported cross-resistance to *p,p'*DDT (8.60), lindane (13.45) and malathion (6.86) in 18.72 times pirimiphos-methyl resistant strain of *T. castaneum*. Similar level of reversion in phosphine resistance in both the primiphos-methyl selected and the non-selected strains indicated no interaction between these two types of resistance. Generally removal of selection pressure of insecticides had resulted in reversion of their resistance (KEIDING, 1967). However, the rate of such regression depends upon the extent of homozygosity that has been achieved and degree of fitness of such individuals (GEORGHIOU, 1972). The present investigation suggested that the degree of reversion in insecticide resistance may also depend upon the kind of insecticide subsequently used in insect control programme.

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PESTILENCE BEHAVIOUR OF APPLE FRUIT MOTH, *ARGYRESTHIA CONJUGELLA* ZELLER (YPONOMEUTIDAE : LEPIDOPTERA)

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Pestilence behaviour of apple fruit moth *Argyresthia conjugella* Zeller was studied during 1983-1984. All the four larval instars feed inside the fruit. White crystalline mass on the fruit is the characteristic symptom of its attack. First instar larva makes straight/zig-zag galleries towards seed pocket, enters the seed and feeds on perisperm. Second, third and fourth instar larvae feed on cotyledons. Fourth instar larva makes an exit hole and comes out of fruit preferably between 6 to 8 AM and pupates under stones, clods and fallen leaves in shady and moist places, below or near apple trees. The moth is nocturnal with photonegative behaviour.

(*Key words*: pestilence behaviour, apple fruit moth, *Argyresthia conjugella*, perisperm, cotyledons)

INTRODUCTION

Apple fruit moth, *Argyresthia conjugella* Zeller is the key pest of apple in Kinnaur District of Himachal Pradesh. Although this pest is causing economic loss for the last five decades, detailed investigations were undertaken only after its identification in 1984 (KHAJURIA *et al.*, 1986). It was perhaps due to parallel pestilence behaviour, the apple fruit moth was misreported as codling moth, *Corpocapsa pomonella* (L.) (SHARMA & BHALLA, 1964) and later as tortricid *Eucosma* sp. (SHARMA & DOGRA, 1979). Since then a long term project has been drawn on biology, behaviour and control of apple fruit moth. Studies on the varietal susceptibility, ecology and chemical control of the pest have been published elsewhere (KHAJURIA *et al.*, 1987, 1988; SHARMA *et al.*, 1988 a, b); the present communication deals with the pestilence behaviour of this pest. Such studies help in finding weak links in the bionomics to be subsequently used in the development of an effective and economic control schedule.

MATERIALS AND METHODS

The studies were conducted in an orchard, known for apple fruit moth infestation, at Kalpa (Kinnaur) during 1983 and 1984. Ten trees of apple cultivar 'Royal Delicious' were selected and were daily observed from June to September, synchronising with the crop maturity and pest infestation period. Field observations were supplemented with laboratory studies. Newly emerged moths, collected from the field, were kept in the cage and were fed on 10 percent honey and sugar solution. Twigs bearing apple fruits were provided for egg laying.

For studies on larval behaviour, 400 fruits showing larval injury were bagged and 10 fruits were opened on alternate days till larval emergence started. The fruits were dissected by making an incision along the entry hole as well as the exit hole, so as to make the entrance and exit/galleries very clear. During examination of infested fruits the size of the entrance and exit holes, length and breadth of inward and outward

galleries, time spent by the larva between entrance to exit, its behaviour inside the fruit and nature and extent of damage caused to the fruits were recorded.

In order to ascertain emergence of the larva, infested fruits were hung over a piece of cloth. The number of larvae emerged at an interval of 2 hours was recorded. Post emergence behaviour of larva was studied both in the laboratory and field. In laboratory, pupation conditions were worked out by releasing larvae in seven different pupation sites (viz., empty glass jars, glass jars with 5 cm layer of moist soil, glass jars with 5 cm layer of moist soil covered with a thick layer of apple and chilgoza leaves and earthen pot with a hole in the centre and moist surface beneath). Each site was supplied with 25 larvae and the experiment was replicated 4 times. Percent pupation in each treatment was calculated.

In field experiment, 200 larvae were released in the basins of 4 apple trees with shady moist conditions. Percent pupation and mortality due to predation and other factors were calculated. Similar experiment was conducted under dry-sunny tree basins.

RESULTS AND DISCUSSION

Moths are small and frail, with a body length of 4.8 to 6.05 mm and a mximum breadth of 1.3 to 1.9 mm. They are photonegative and remained hidden either in the bushes or on the undersurface of the apple leaves during the day and between 7 to 9 PM they fly in the vicinity of the apple trees. The resting posture of the moth is peculiar as during resting its abdomen and hindlegs are obtusely directed thereby giving an upside down appearance. Egglaying in the laboratory failed and the moths died in 4 to 8 days. Egglaying in the field was also not observed. Our findings receive support from MACDAUGALL (1926); however AHLBERG (1927) and STAPLEY (1934) observed egg laying both in the field and laboratory. In the absence of defiinite information, it can only be conjectured that eggs are laid at dusk on the apple fruit or incubation period is short and immediately after hatching the larva bores into the fruit and a white speck on the fruit is the crystallized juice of apple fruit around egg shell, as a result of which egg shell is not visible.

Behaviour of the larva:

First instar: Immediately after hatching, the larva bores into the fruit through a minute hole 0.129 to 0.144 mm (average 0.136 mm) in diameter. The entrance holes were normally on shady side of the fruit. About 60 percent larvae entered from the calyx and remaining 40 percent from other sides. Normally, 1 to 9 larvae/fruit were counted but in one case as many as 35 larvae entered the fruit out of which 10 were recovered. The previous record was 25 larvae/fruit (AHLBERG, 1927; STAPLEY, 1934; BELOSEL'S KAYA, 1963). The adult emergence started when fruits were 2.7 to 3.2 cm (average 2.95 cm) in diameter and seeds were fully developed.

The larval entry was marked by the milky white crystalline ooze of different shapes and sizes. A minute entrance hole was invariably visible after removing the crystalline ooze. Through an incision along this hole the larval passage can be traced. These observations support the findings of AHLBERG (1927) and BELOSEL'S KAYA (1963). Heavily mined fruits were distorted and uneven, due to slow growth around the infested area. After traversing the pericarp the larva tunneled the seed pocket by making a zig-zag gallery of 1.2 to 5.5 cm long and 0.13 to 0.16 mm diameter. The difference in length was governed by the site of entry and size of the fruit. The larva, that entered from the calyx end of the fruit had short and straight galleries, while

others entering from top and middle of the fruit had long and zig-zag galleries. However, the principle guiding the navigation of the larva towards the seed pocket is not known and in the absence of definite information it is assumed that chaemotactic and/or mechanotactic response(s) guide the larva towards the seed core. The galleries were brown due to oxidaion of phenols and faeces of larvae.

After the larva reached seed pocket, it moved towards the seed and entered it from its basal end. The larva then moved between the seed coats, testa and tegumen, and crawled towards distal end of the seed, as evident by the light brown track on its lateral sides. The testa was initially white but later turned dark brown. At the distal end of the seed, the larva fed for 2 to 4 days on the paste like part of seed embryo called perisperm. The first instar larva with poorly developed mouth parts preferred perisperm. Thereafter, it entered the cotyledons by puncturing the tegumen. In 1983, it moulted in 6.0 to 8.2 days of its entry inside the fruit and in 1984 in 7.0 to 8.3 days. Usually there was one larva per seed. Sometimes there were two larvae and invariably one of them died during development. Perhaps the larva entering earlier consumed the perisperm, the main food of the first instar larva.

Second instar: The larva fed on the cotyledons by burrowing into them. The burrows were identified by the light brown frass. The creamy-white second instar larva moulted to third instar in 6.4 to 7.2 days in 1983 and 5.7 to 6.2 days in 1984.

Third instar: The larva also fed on cotyledons for 5.6 to 6.5 and 4.8 to 5.4 days during 1983 and 1984, respectively. The light-yellow larva turned greenish before moulting to fourth instar.

Fourth instar: The larva fed on cotyledons for 5 to 7 and 4 to 6 days during 1983 and 1984, respectively. The full fed larva occupied the entire seed space. At this stage the cotyledons were reduced to a lump of brown mass of faeces and remnant of cotyledons. The infested seeds contained dark-brown to black spots at the distal end. Present observations confirm the earlier findings of AHLBERG (1927) and BELOSEL's KAYA (1963).

After 18 to 20 days of feeding, the larva starts moving towards the exit. It leaves the seed pocket, now full of brown frass to the exit hole on the upper side through a straight gallery towards upper side of the fruit or rarely through a zig-zag gallery in the middle of the fruit. The galleries were always brown, 2.2 to 3.7 mm long, and 1.0 to 1.2 mm in diameter, and contain frass. The exit hole was 0.95 to 1.11 mm in diameter. A week after larval emergence, the exit hole turned black which was prominent in 'Golden Delicious' due to golden background. Emergence of the larvae took place mostly before sunrise. The experiment on emergence behaviour in the laboratory showed that maximum emergence took place between 4 AM to 8 AM with peak at or around 6 AM (Table 1). It, however, continued unabaited for twenty four hours at different rates.

The brick-red fourth instar larva had a duration of 8.5 to 11.0 and 7.6 to 9.8 days during 1983 and 1984, respectively. The total time spent by the larva inside the fruit ranged between 26.5 to 32.9 days in 1983 and 25.1 to 29.7 days in 1984.

After exit, the larva rested on the fruit for 5 to 15 minutes, sometimes it crawled on the fruit. Thereafter it descended by spinning a silken thread and reached the ground in 2 to 5 minutes, depending upon the distance of the fruit from the ground. The

TABLE 1. Time of emergence of apple fruit moth larvae from fruits under laboratory condition.

Time of observation (Hours)	Total larvae emerged during peak period of emergence	
	1983*	1984**
1400	7	9
1600	12	13
1800	12	26
2000	9	14
2200	7	13
0000	4	2
0400	26	78
0600	115	208
0800	81	131
1000	17	47
1200	5	12

* Mean of 19 observations.
** Mean of 18 observations.

descending took place in phases. In the first phase, it descended for 20 to 25 cm and hung with the silken thread. Thereafter, it spun the thread and further slided down, the process was repeated 3 to 5 times till the larva touched the ground. Sometimes the larva slipped down after leaving the fruit.

Pupation behaviour: The larva after reaching the ground, wandered for a suitable pupation site. Maximum pupation, 70.5 and 81.5% took place under the trees with moist and shady basins below the stones, fallen leaves, soil clods and cracks and crevices; whereas only 19.5 and 15.75 percent larvae moved away to pupate in the adjoining terraces in both the years 1984 and 1985, respectively. Under the trees with sunny basins, 40 and 40.75 percent larvae pupated in the adjoining terraces, 10.5 and 15.25 percent under tree basins in cracks and soil clods. 17.0 and 17.5 percent died perhaps due to exhaustion and the rest were preyed upon by the ants during 1983 and 1984, respectively. Thus under field conditions percent pupation ranged between 50 to 90.

In laboratory, 80 percent larvae pupated beneath earthen pots, 64 percent in glass jar containing 5 cm thick moist soil and the leaves of apple and chilgoza, and 60 percent in jars with 5 cm moist soil covered with three layers of stones. No pupation took place in empty jars. MACDAUGALL (1926), AHLBERG (1927) and BELOSEL'S KAYA (1963) also reported maximum pupation under stones, dead leaves and soil. However, they also reported some pupation on the fruits and under the bark of the tree trunk which was not observed in the present studies.

The larvae pupated by spinning two layered white spindle shaped cocoon, the outer layer was loose and net like and the inner dense and fusiform. The time taken to spin the cocoon ranged between 24 to 36 hours and for pupation 2 to 3 days which is almost similar to that reported by STAPLEY (1934) from England. The pupal period was 281 days in the present studies against 255 to 285 days in Japan (OKAMOTO, 1917), 180 to 240 days in Sweden (AHLBERG, 1927), 270 days in England (STAPELY, 1934) and 240 to 270 days in Switzerland (BOVEY, 1935). STAPLEY (1934) observed few pupae emerging even after two years. This difference was perhaps due to different agroclimatic conditions. Some of the earlier workers (AHLBERG, 1927; BOVEY, 1935) reported both larval and pupal diapause which does not seem to be the case in the present studies. However, in the present studies only pupal diapause was observed. Nevertheless, further studies are in progress.

Therefore, it is evident from the above discussion that the pest can be easily managed with suitable insecticides before the enttrance of larvae into the fruits. Second possibility is to kill the larvae after their emergence from the fruits, but before pupation. For this suitable insecticidal dusts can be tried to treat the tree basins, so as to kill the larvae before pupation. The clear tree basins devoid of suitable pupation sites would also be very useful in reducing the pest infestation in subsequent years. Thus these vital informations on the behaviour should be taken into consideration for devising suitable control measures against this pest.

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ANTIBIOSIS IN CHICKPEA (*CICER ARIETINUM* L.) TO GRAM POD BORER, *HELIOTHIS ARMIGERA* (HUBNER) (NOCTUIDAE: LEPIDOPTERA) IN INDIA

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The antibiotic effect of the chickpea genotypes 'ICCX-730041', 'ICC-10613', 'ICC-10817', 'ICCL-79048' (less susceptible), 'C-235' (moderately susceptible) and 'K-850', 'ICC-1403' and 'ICC-3137' (more susceptible) against gram pod borer, *Heliothis armigera* (Hubner) was studied at Udaipur during 1985. The genotypes showed a wide variability in larval survival (77-90%), larval weight (333-436mg/larva), pupal weight (231-310 mg/pupa), egg viability (55-78.5%), adult longevity, 8-10 days in males and 10-12 days in females and Howe's growth index 0.079-0.099 depending upon the susceptibility. The genotypes were grouped into five clusters and the inter and intra-cluster distances were worked out.

(*Key words*: *Heliothis armigera*, chickpea, resistance, antibiosis)

INTRODUCTION

Heliothis armigera (Hübner) is a key pest and is one of the limiting factors in the successful cultivation of chickpea. The pod damage has been found to range from 0 to 84.4% (SITHANANTHAM et al., 1984). The monetary loss is estimated upto 2030 million rupees annually (LAL et al., 1985). Chickpea varieties however differ in their susceptibility to *H. armigera* due to differences in antibiosis mechanism (SINGH & SHARMA, 1970). Work on antibiosis to *H. armigera* in different crops, including chickpea has been reported by COAKER (1959), DHANDAPANI & BALASUBRAMANIAN (1980), DUBEY et al. (1981) and JAYARAJ (1982). The present investigation is a further contribution on antibiosis to pod borer in chickpea.

MATERIAL AND METHODS

The experiment was carried out at Udaipur during the post-rainy season of 1985. The genotypes used were 'ICCX–730041', 'ICC–10817', 'ICCL–79048' (less susceptible), 'C–235' (moderately susceptible) and 'K–850, 'ICC–1403', 'ICC–3137' (more susceptible) as reported by Lateef, ICRISAT (personal communication). The genotypes were grown as per recommended agronomic practices, without any pesticide application.

The experiment was conducted in a controlled chamber maintained at 26 ± 1°C and 80 ± 5% relative humidity with 12 hours photophase and 12 hours scotophase. The developmental study was conducted on 30 individual larvae grouped into three replications of 10 larvae each. The newly hatched larvae were released in separate vials (5 × 2.5 cm) containing fresh leaves of the test genotype with the help of a camel hair brush. The larvae were fed leaves for first five days, next 5 days on buds and flowers and further on pods.

Data on various growth and developmental parameters of *H. armigera* were recorded from each replication (Tables 1 and 2).

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For larval and pupal weights, five 10-day-old larvae and five 10-day-old pupae were taken from each replication. For fecundity, two pairs of newly emerged adults, collected at random from each replicate, were confined in oviposition jars separately for each pair and each replicate. The data collected were analyzed in completely randomized design.

Mahalanobis D^2 analysis as used by RAO (1970) was applied to find out the genetic diversity in test genotypes in relation to the growth and development of *H. armigera*. Percent contribution of an individual parameter in creating diversity in developmental behaviour of *H. armigera* was calculated as under.

$$\text{Percent contribution} = \frac{N \times 100}{n\,(n-1)/2}$$

Where N = number of times a particular character ranked first.

n = number of treatments.

RESULTS AND DISCUSSION

Larval survival:

The percent larval survival on different genotypes differed significantly. It was lowest on 'ICCL-79048' (76.8%) and this exhibited a higher degree of antibiosis (Table 1).

TABLE 1. Antibiotic influence of chickpea genotypes on the larval survival, larval weight, larval period, growth index, pupal wight, pupal period and pupal survival of *Heliothis armigera*.

Genotype	Mean larval survival [%]	Mean larval weight [mg/larva]	Mean larval period [days]	*Howe's growth index	Mean pupal weight [mg/pupa]	Mean pupal period [days]	Mean pupal survival* [%]
'ICCX-730041'	83.65 (66.14)	337.3	22.1	0.087	231.0	14.6	83.65 (66.14)
'ICC-10613'	80.00 (63.43)	344.7	21.3	0.089	248.7	13.8	80.00 (63.43)
'ICC-10817'	83.65 (66.14)	333.0	23.0	0.084	249.0	14.9	83.65 (66.14)
'ICCL-79048'	76.80 (61.22)	356.0	24.0	0.079	252.7	14.7	76.80 (61.22)
'C-235'	83.65 (66.14)	382.0	21.2	0.091	260.3	13.9	83.65 (66.14)
'K-850'	90.00 (71.57)	429.3	19.9	0.098	282.7	12.6	90.00 (71.57)
'ICC-1403'	87.00 (68.86)	388.0	20.7	0.094	268.3	12.5	87.00 (68.86)
'ICC-3137'	90.00 (71.57)	436.7	19.8	0.099	310.3	12.7	90.00 (71.57)
S Em±	2.07	5.13	0.14	—	3.91	0.17	2.07
CD at 5%	6.20	15.40	0.40	—	11.70	0.50	6.20

*Howe's growth index $= \frac{\text{Log percent larval survival}}{\text{Mean larval period in days}}$.

Mean larvel and pupal survival percentage was calculated from the initial number of larvae released. (Figures in parentheses are arc-sin values).

Whereas it was highest on 'K–850' and 'ICC–3137' (90%), which showed that these two genotypes proved more suitable for the survival of larvae. DUBEY *et al.* (1981) have studied the antibiotic influence of various food plants on the developmental stages of *H. armigera*. They reported highest larval survival on lucerne and lowest on pea.

Larval weight :

The mean larval weight of the 10-day old larvae reared on different genotypes differed significantly. It was highest on 'ICC-3137' (436.7 mg) and lowest on 'ICC–10817' (333.0 mg). This indicates that 'ICC–10817' exhibited more antibiosis. DUBBEY *et al.* (1981) recorded significantly lower weight of the larvae fed on pea than on other plants under investigtion.

Larval period :

Table 1 shows that the average larval period on different genotypes differed significantly. It was longest (24 days) on 'ICCL–79048', which indicate more antibiosis in this genotypes. COAKER (1959) reported more antibiosis by sunflower corolla than maize silk with respect to average larval period.

Growth index :

'ICC–3137' and 'ICCL–79048' showed the highest (0.099) and lowest (0.079) Howe's growth index respectively (Table 1). This suggest that 'ICCL–79048' exhibited the highest level of antibiosis.

Pupal weight :

Data in Table 1 show that the mean pupal weight of 10 day old pupae developed on different genotypes differed significantly. It was highest on 'ICC–3137' and lowest on 'ICCX–730041' which indicate the pupae will be heavier on susceptible genotypes and lighter on resistant ones.

Pupal period :

Table 1 shows that the average pupal period on different genotypes differed significantly. It was longest on 'ICC–10817' and shortest on 'ICC–1403'. DUBEY et al. (1981) have studied the antibiotic effect of various food plants on pupal period and reported significantly shorter pupal period on lucerne and pigeonpea than on chickpea.

Pupal survival and adult emergence :

All the larvae fed on different genotypes, which survived upto prepupal stage, pupated successfully (Table 1). As there was no pupal mortality and adults emerged from all the pupa formed, the percent adult emergence was same as the percent pupal survival.

Sex ratio :

Table 2 shows that females outnumbered the males, when reared on 'ICC–3137', whereas males outnumbered the females with a slight margin on less susceptible genotypes.

Fecundity and egg viability :

The fecundity and egg viability of adults developed on different genotypes did not differ significantly.

Adult longevity :

The longevity of male and female moths developed on different genotypes did not differ significantly. However the females produced by all genotypes survived longer than males, produced from corresponding genotypes.

Mahalanobis D^2 statistics :

Growth and developmental parameters which differed significantly were chosen for this analysis. These parameters were larval survival, larval weight, average larval period, pupal weight and average pupal period. By

TABLE 2. Antibiotic influence of chickpea genotypes on adult emergence, sex ratio, facundity, egg viability and adult longevity of *Heliothis armigera*.

Genotype	Mean adult emergence* (%)	Sex ratio		No.of eggs laid/female	Viability of eggs (%)	Mean adult longevity (days)	
		Male	Female			Male	Female
'ICCX–730041'	83.65 (66.14)	1	0.8	338.3	59.7 (50.6)	8.3	10.0
'ICC–10613'	80.00 (63.43)	1	0.8	323.7	54.7 (47.7)	7.7	10.0
'ICC–10817'	83.65 (66.14)	1	0.7	344.7	63.2 (52.7)	8.0	10.7
'ICCL–79048'	76.80 (61.22)	1	0.9	303.0	58.0 (49.6)	10.0	10.7
'C–235'	83.65 (66.14)	1	0.8	383.0	62.9 (52.5)	9.0	11.0
'K–850'	90.00 (71.57)	1	0.9	379.0	66.3 (54.5)	9.3	12.3
'ICC–1403'	87.00 (68.86)	1	1.0	329.7	66.0 (54.3)	9.7	11.7
'ICC–3137'	90.00 (71.57)	1	1.1	402.3	78.5 (62.4)	10.0	12.0
S. Em±	(2.07)	—	—	25.6	(3.04)	0.66	0.77
CD at 5%	6.20	—	—	NS	NS	NS	NS

*Percent adult emergence was calculated from the initial number of larvae released.

Figures in parentheses are arc-sin values.

using D^2 statistics, all the genotypes were grouped into five clusters (Fig. 1). These clusters show the groupings of genotypes based on the response of growth and developmental parameters of *H. armigera* on them. For example cluster A, in this cluster there are two genotypes, which mean the groth and development of *H. armigera* showed a similar response towards these two genotypes. The inter cluster distance was highest between cluster B (which consist of the 'ICC–3137' and 'K–850', (the more susceptible genotypes) and cluster D (which comprised 'ICCL–79048' the less susceptible genotype). This means that the growth and development of *H. armigera* responded differently on the genotypes in cluster B than on genotype in cluster D. This intra-cluster distance was highest in cluster C and lowest in cluster A, which mean the genotypes in cluster A were more closer to each other than the genotypes in cluster C in their influence on growth and development of *H. armigera*.

The contribution of different parameters in creating diversity in feeding and development of this insect was also measured by using D^2 statistics. It was observed that larval weight contributed maximum, 50% followed by average larval period, pupal weight and average pupal period 32.1, 14.3 and 3.6% respectively.

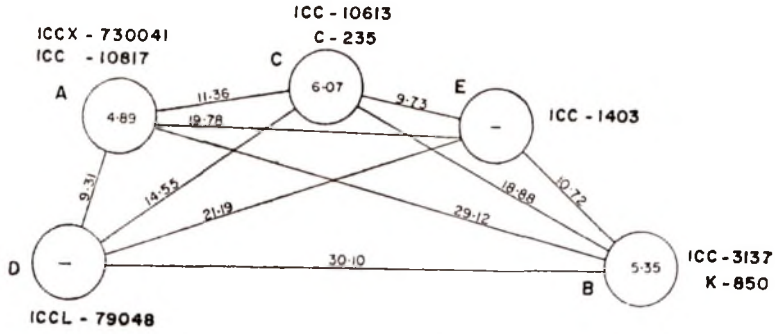

Figure 1. Intra- and inter-cluster distances among different genotypes of chickpea based on their effect on the growth and development of *Heliothis armigera*.

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CONSUMPTION AND UTILIZATION OF FOOD BY ERI SILKWORM *SAMIA CYNTHIA RICINI* BOISDUVAL

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Studies on consumption and utilization of food by eri silkworm on three castor varieties viz., 'Local' 'Aruna' and 'RC-8' and on tapioca var. 'Mangalore Local' were conducted at mean temperature of 22± 1°C and relative humidity of 78 ±3%. The rate of ingestion (CI), though, did not significantly differ among the hosts on fresh weight basis, tapioca recorded significantly highest (6.004g/g body weight/day) on dry weight basis. The approximate digestibility (AD) was significantly highest on 'Local' variety of castor/(80.80%) on fresh weight basis. The highest growth rate (GR) was observed on 'Local' variety of castor. The conversion efficiency of ingested (ECI) and digested (ECD) food into body matter was higher in larvae reared on 'Aruna' variety of catstor.

(*Key words*: consumption, digestibility, conversion efficiency, utilization, eri silkworm)

INTRODUCTION

Studies on nutritional ecology of an insect is very important for its commercial exploitation (SCRIBER & SLANSKY, 1981). A need for such studies is the estimation of rate of ingestion, digestibility and conversion efficiency of food, so also, growth rate of the animal, etc. (ENGLEMANN, 1966).

Eri silkworm is a sericigenous insect exploited for its valuable silk. Since it feeds on many hosts, the study of nutritional ecology is essential to select a best host for its commercial exploitation. Studies by EL-SHAARAWY *et al.* (1975), POONIA (1978, 1985), REDDY (1983) and JOSHI (1984) reveals lack of literature on the consumption and utilization of different varieties of castor and other food plants. The present investigation aims at determining the rate of food consumption, digestibility, growth rate and conversion efficiency of three castor varieties viz., 'Local' 'Aruna' and 'RC-8', and tapioca variety 'Mangalore Local' both on fresh and dry weight basis.

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MATERIAL AND METHODS

Simultaneously hatched larvae were reared at a mean temperature of 22 ± 1°C and 78 ± 3% relative humidity on four different hosts, each with 100 larvae replicated five times. A bulk culture of worms was separately maintained under identical conditions to replace the dead larvae. All the weights needed for the study were recorded both on fresh and dry weight basis in a monopan Sartorius balance.

Once a day the residual food and excreta were carefully separated, weighed and oven dried at 80 ± 5°C to constant weight. Weights of five larvae selected randomly were recorded at he beginning of each instar before the first feed and then at the end of each instar. The same larvae were freeze-killed and oven dried at 100 ± 5°C to constant weight to record the dry weight.

In order to account for the moisture loss from the leaves during the feeding period, a separate sample of the leaf bits were weighed and kept under identical conditions without

worms. The same was reweighed when the residual food in the experimental batch was weighed. The nutritional parameters of the food in the form of CI, AD, GR, ECI and ECD were calculated by gravimetric method. (WALDBAUER, 1968). The data was statistically analysed as completely randomized design to determine statistical significance (PANSE & SUKHATME, 1985).

RESULTS AND DISCUSSION

Consumption Index (CI): The data on food consumption index on four hosts are presented in Table 1. The results showed that the CI on four hosts do not significantly differ on fresh weight basis indicating that the hosts, castor and tapioca, were taken in at the same rate, but was significntly higher on tapioca (6.004 g/g body weight per day) and lower on 'Aruna' variety of castor (4.016 g/g body weight/day) on dry weight basis. MEHTA & SAXENA (1973) opined that nutritional inferiority of a diet may be compensated to some extent by increased rate of food intake. The higher CI on tapioca on dry weight basis may be due to its poor nutritional value. WALDBAUER (1964) and SOO HOO & FRAENKEL (1966) reported that CI on dry weight basis was higher than on fresh weight due to lesser dry matter content in the insect body than the food. Their observations support the present results.

Approximate digestibility (AD): The digestibility of food is represented as AD and the data are presented in Table 1. The AD on fresh weight basis was significantly higher on 'Local' variety of castor (80.8%) and lower on 'RC–8' variety of castor (73.28%) and tapioca (74.16%) which did not differ significantly. The AD on dry weight basis did not show significant difference among the hosts. The digestibility of food mainly depends on the physicochemical properties of the food and enzymatic role (SOO HOO & FRAENKEL, 1966). Further, the variations between fresh and dry weight basis are mainly due to varied amount of moisture content in the food and excreta.

Growth Rate (GR): The data on growth rate, presented in Table 2, showed significantly higher GR on Local variety of castor and lower on tapioca, both on fresh and dry weight basis, whereas 'Aruna' and 'RC–8' varieties of castor are inermediate in position. VENKATARAMANA & BHATT (1960), SIDHU *et al.* (1969) and KRISHNASWAMI *et al.* (1971) reported that the GR in *Bombyx mori*

TABLE 1. Consumption index (CI) and approximate digestibility (AD) of eri silkworm on different hosts.

Host	CI		AD	
	F.W.	D.W.	F.W.	D.W.
Castor : Var. 'Local'	2.311	4.864[a]	80.80	59.99
Castor : Var. 'Aruna'	2.402	4.016	76.56	56.92
Castor : Var. 'RC–8'	2.374	4.853[a]	73.28[a]	57.69
Tapioca : Var. 'Mangalore Local'	2.195	6.004	74.16[a]	59.89
SE	NS	0.265	0.67	NS
CD ($P=0.05$)		0.563	1.42	

Values with same superscripts are not significantly different.
F.W. = Fresh weight basis.
D.W. = Dry weight basis.

depends on the nutritional status of the food. Further, MEHTA & SAXENA (1973) reported that the GR directly depends on utilization of the nutrients in the food. In this context, tapioca was considered as poor food or less utilized food by the eri silkworm.

Conversion Efficiency: The data on conversion efficiency of ingested (ECI) and digested food (ECD) into body matter are presented in Table 2.

Efficiency of Conversion of Ingested food (ECI)

The ECI was significantly lower on tapioca (20.33%) and highr on castor varieties which are not significantly different from each other on fresh weight basis. The ECI was significantly higher on 'Aruna' (12.53%) variety of castor and lower on tapioca (7.45%) on dry weight basis, 'local' (11.60%) and 'RC–8' (11.10%) varieties of castor stands in between.

Efficiency of Conversion of Digested food (ECD): The ECD was significantly higher on 'RC–8' (38.09%) and 'Aruna' (36.84%) and lowest on tapioca (29.47%) on fresh weight basis, that on dry weight basis the four hosts did not significantly differ.

The conversion of food into body matter both on fresh and dry weight basis clearly shows the retention of higher amount of water from the food in the larvae reared on tapioca than on castor. Carbohydrate metabolism in the insect body also contributes a small percent of water. Hence, the larvae reared on tapioca retained water both from the leaves and from the carbohydrate metabolism. The less conversion efficiency of tapioca by the larvae may be due to the poor/unbalanced nutrition of the host.

The results on nutritional indices reveal that the tapioca was consumed at higher rate but the digestibility and conversion efficiency were less which results in lower growth rate. Among the castor varieties though marked differences were not observed, the 'Aruna' variety of castor performed better with respect to all indices discussed.

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TABLE 2. Growth rate and conversion efficiency of eri silkworm on different hosts.

Host	GR		ECI		ECD	
	F.W.	D.W.	F.W.	D.W.	F.W.	D.W.
Castor: var. 'Local'	0.52	0.48	26.05[a]	11.00[a]	33.35	19.35
Castor : var. 'Aruna'	0.47[a]	0.43[a]	26.13[a]	12.53	36.84[a]	22.74
Castor : var. 'RC–8'	0.47[a]	0.42[a]	25.67[a]	11.10[a]	38.09[a]	21.08
Tapioca : var. 'Mangalore Local'	0.36	0.33	20.33	7.45	29.47	14.34
SE	0.005	0.02	1.25	0.55	0.99	NS
C.D. ($P=0.05$)	0.01	0.04	2.66	1.17	2.11	

Value with same supercripts are not significantly different.

F.W. = Fresh weight basis; D.W. = Dry weight basis.

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BRIEF COMMUNICATION

KARYOMORPHOLOGICAL STUDIES OF AN INDIAN POPULATION OF BROWN PLANTHOPPER (*NILAPARVATA LUNGENS* (STAL)

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(*Received* 6 *October* 1988)

Karyological studies of brown planthopper culture of Annamalainagar revealed $2n = 30$ chromosomes consisting of 14 pairs of autosomes in both sexes plus an unequal XY pair in males and supposed to be equal YX pairs in females confirming reports from other countries.

(*Key words*: karyomorphology, chromosomes, brown planthopper)

Cytological studies in recent times are being considered as one of the routes to the biotypic characterization of insect species (NAITO, 1982; SAXENA & BARRION, 1983b; TYAGI, 1983). Brown planthopper (BPH), *Nilaparvata lugens* (Stal), one of the important pests on rice that exists in the form of many biotypic populations, has not been studied cytologically so far in this subcontinent, for which the present chromosomal investigation was undertaken.

A stock culture of the BPH of Annamalainagar is being maintained on 'TN 1' rice from 1982 onwards and from this colony fifth instar nymphs and fresh adult males were used for chromosome preparation. Following the procedure of SAXENA & BARRION (1982) chromosomal preparations were made. The material thus mounted was used for microscopic examination.

Fixing and dissection of insects directly in the fixative, Carnoy's fluid, incising the insect body along lateral sides and ringing the coverslip with a preparation of thermocol dissolved in xylol are the improvements over the earlier method. Metabolic activities were noticed to take place between 1200–1330 hours during summer season and 1445–1545 hours in winter season.

The genomic complement in the BPH was found to be $2n = 30$ in males (Figs. 1, 2, 5). These consisted of 14 bivalent autosomal pairs and XY univalent sex chromosomes in males; in females it could be 15 (XX) pairs of elements. The sex determining system was therefore, an XX–XY type, the males being heterogametic (14 II + XY) or producing two types of secondary spermatocytes, 14 I + X and 14 I + Y, while the females were homogametic (14 II + XX) or producing single type of secondary oocytes, 14 I + X.

The total number of chromosomes was the same as that of its counterpart in the Phillippines (CLARIDGE, 1979; SAXENA & BARRION, 1983a). A chromosome number of $2n = 29$ for BPH was earlier arrived at by SAITOH *et al.* (1970) and LIQUIDO (1978). But the subsequent findings including the current investigation clarified the previous revelation and expressed the number as 30. Of the forty odd species of Delphacidae studied so far, the chromosome numbers have been reported to range from 24 to 37 with a

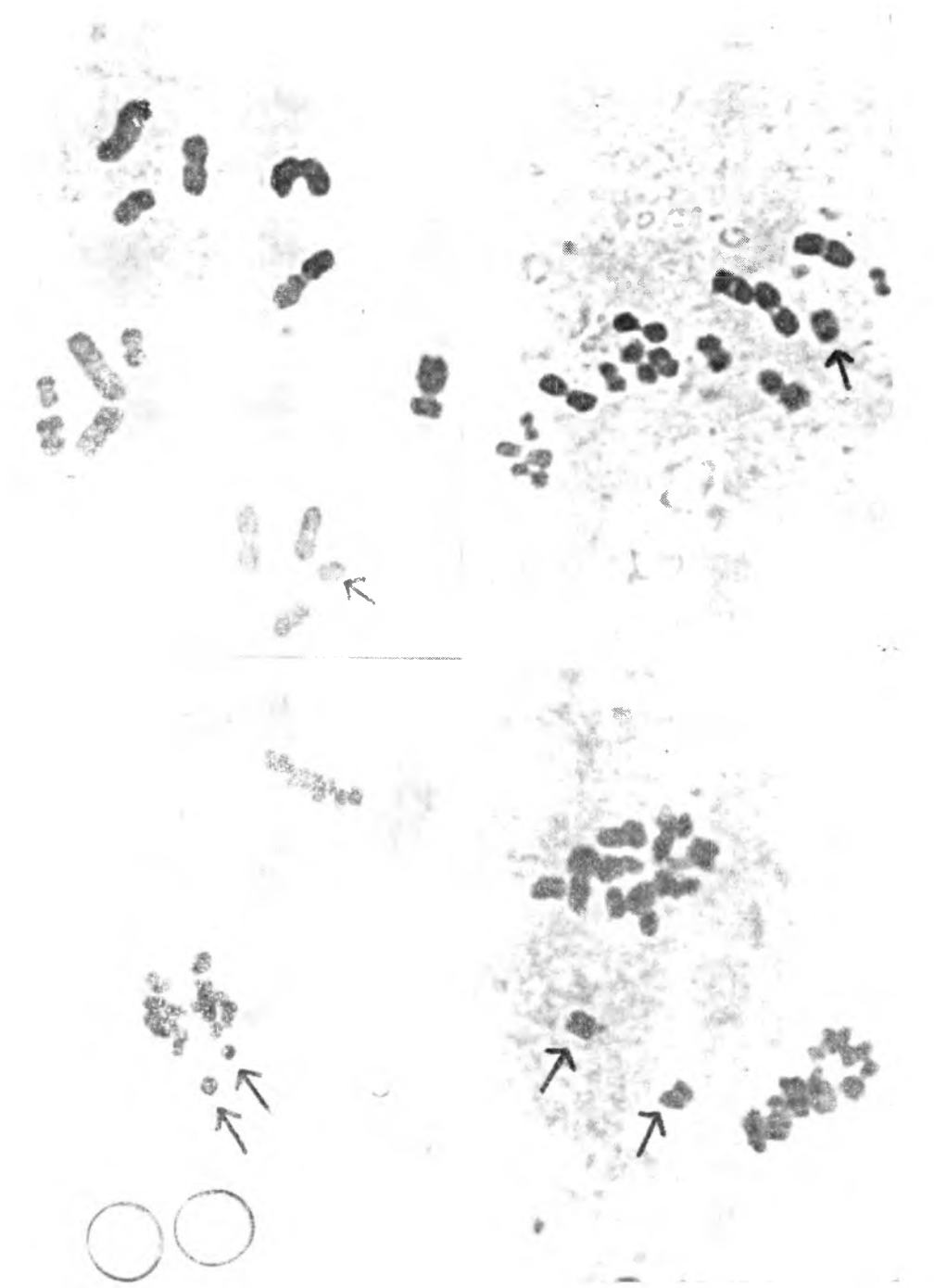

Fig. 1. Meiotic chromosomes of BPH males. Early metaphase I Chromosomes in testicular cells (sex chromosomes indicated by arrows) polar view. Fig. 2. Metaphase I Side view (sex chromosomes indicated by arrows). Fig. 3. Metaphase I — Chromosomes — Side view (sex chromosomes indicted by arrows). Fig. 4. Anaphase I — with sex chromosomes lagging.

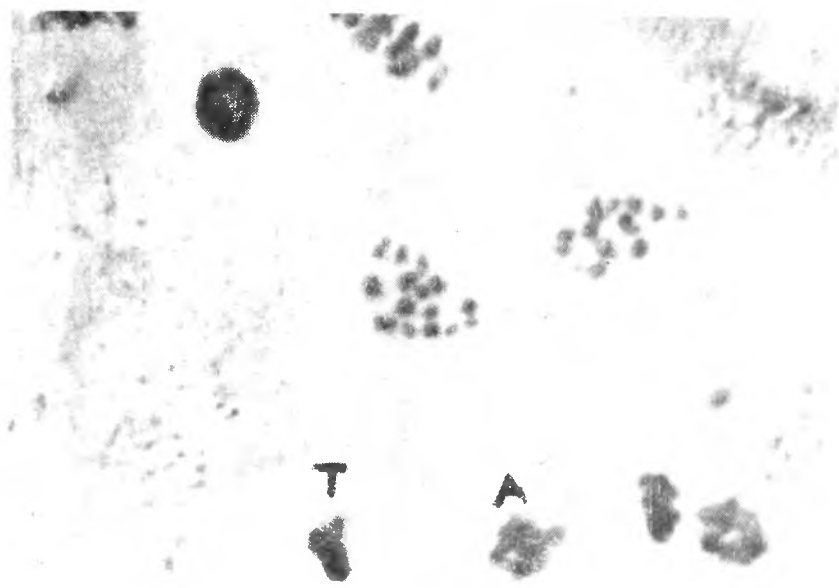

Fig. 5. Anaphase I (A) and Telophase I (T).

peak at 29 (BHATTACHARYA & MANNA, 1973). Therefore the presence of 30 chromosomes in BPH might suggest a case of fragmentation. During Metaphase I and Anaphase I stages the two sex chromosomes lagged behind and apart with definite hiatus (1.90 μm) from the autosomal clump (Figs. 3, 4) thus confirming the total number of chromosomes (which break off into two masses each with 14 numbers with a sex chromosome held apart). The autosomes measured a length of 10.50 μm and 2.20 μm in width and *X* and *Y* sex chromosomes were of 3.00 μm and 2.75 μm in length and 2.20 μm and 2.00 μm in width respectively.

The length and width of sex chromosome *X* of this Indian population were lower than those reported for IRRI biotypes. On the other hand the size of *Y* chromosome in IRRI biotypes 1, 2 and 3 was similar to the Indian population (SAXENA & BARRION, 1983a). There were entirely different anaphase and telophase stages including the morphometrics of the chromosomes of IRRI biotypes. Based on these characteristics, it is inferred that brown planthoppers of Indian origin are genetically almost similar to their counterparts in other countries though there are some micro-variations in the morphometrics of the chromosomes.

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BRIEF COMMUNICATION

ENDOCRINE GLANDS IN THE LAST INSTAR LARVA OF *OPISINA ARENOSELLA* WALKER (LEPIDOPTERA : XYLORYCTINAE)

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The final (eighth) instar larva of the black headed caterpillar of coconut tree, *Opisina arenosella* Walker has two groups of median pars intercerebralis neurosecretory cells (M_1 and M_2) and two groups of lateral neurosecretory cells (L_1 and L_2) in the brain, on each side. M_1, the major group, consists of A (larger and smaller), B and C cells. The other groups consist of two A-cells each, in each half of the brain. The corpus cardiacum and the corpus allatum of each side form a single complex. Each prothoracic gland is made up of a maximum of 30 cells, and is innervated by five nerves: two from suboesophageal, two from prothoracic and one from mesothoracic ganglia.

(*Key words*: final (eighth) instar larva, black headed caterpillar, *Opisina arenosella*, endocrine glands, brain neurosecretory cells, corpus cardiacum–corpus allatum complex, prothoracic glands, innervation)

Opisina arenosella Walker, a notorious coconut pest popularly known as the black-headed caterpillar, whose larvae feed and destroy the green parenchymatous tissue of the leaflets, is being studied in our laboratory in detail. This animal has eight larval instars (SANTHOSH-BABU & PRABHU, 1987). The final (8th) instar of this insect which has a duration of 7–8 days, is being used for ligaturing studies as reported elsewhere in this volume (GEETHA et al., 1990), and hence the results of our studies on the endorcrine system of this instar is of particular significance and is briefly reported here.

The insects were reared as already reported (SANTHOSH-BABU & PRABHU, 1987). Anaesthetised eighth instar larvae were dissected in wax-bottomed Petri-dish using insect-Ringer (EPHRUSI & BEADLE, 1936) under a stereoscopic dissection microscope. For histological studies, brain and corpus cardiacum-corpus allatum complex (CC–CA) were fixed in Bouin's fluid or in formol-saline; brain was either processed whole and stained in Humberstone's performic acid – Victoria blue method (DOGRA & TANDON, 1964) and mounted after removal of the nerve sheath, or the brain together with the CC–CA complex was cut at 10 μm thickness and the sections stained with paraldehyde fuchsin (CAMERON & STEELLE, 1959), chrome-alum haematoxylin phloxin (GOMORI, 1941) or by Heidenhain's azan method (RAABE, 1965). The CC–CA complex was also studied using Ehrlich's haematoxylin-eosin. The prothoracic glands (PTG) of 1st, 3rd, 5th and 7th day of the last instar were studied either under phase contrast or was fixed in Bouin's fluid and stained in Ehrlich's haematoxylin. The size of he cells and nuclei of the PTG was measured using a calibrated eyepiece micrometer and the cell volume was calculated using the formula $4/3\pi r^3$ or $4/3\pi\ ab^2$ (PENZLIN, 1971) depending upon whether the cells were spherical or oval.

The endocrine organs include the neurosecretory cells mainly situated in the brain

(Fig. 1); the corpora cardiaca (CC), the corpora allata (CA) and the prothoracic glands (Fig. 2). To surface view, pars intercerebralis neurosecretory cells (PNSC) appear as white spots on the dorsal side of the brain under the stereomicroscope. The corpus cardiacum is situated just behind the brain. At its hind margin it is fused with the anterior portion of the corpus allatum situated behind, to form a single translucent structure the corpus cardiacum-allatum complex (CC–CA), being paired, seen on either side of the aorta (Fig. 3). Neck ligature (GEETHA et al., 1990) hence cuts off the brain–CC–CA complex from the hind region. The PTG are a pair of ribbon-shaped, beaded, usually triradiate organs, consisting of spherical or oval cells attached end to end, occurring near the first spiracle, on eithr side of the aorta and are ventral to the thoracic fat body connected to the tracheae. The gland is enclosed in a thin cellular closely adherent peripheral membranous sheath which maintains the structural integrity of the gland. The main body of the gland usually bears one or two cell-less areas within the membranous sheath. The cells are more closely packed in the posterior limb of the gland. Anteriorly, the gland extends upto the CC–CA complex and posteriorly it extends upto the ventral nerve cord. It is confined mostly to the prothorax and hence thorax ligature (GEETHA et al., 1990) cuts off all the endocrine glands from the hinder portion. The PTG is innervated. There are two nerves from the suboesophageal ganglion, two from prothoracic ganglion and one from mesothoracic ganglion, supplying each PTG. On the first day of emergence of the 8th instar each PTG has 18–23 cells; on the 5th–7th day there are 25–30 cells. Division appears to be mitotic. Phase contrast studies indicate that the cells as well as their nuclei are biggest and presumably most active, on the 5th day.

In each half of the brain two groups of median (M_1 and M_2) and two groups of lateral (L_1 and L_2) neurosecretory cells are present, as shown in Fig. 1. The M_1 group (Fig. 5) is made up of A, B and C types. A–cells, 8 in number, stain deep purple with paraldehyde fuchsin, blue black with CHP and with Victoria blue, but do not

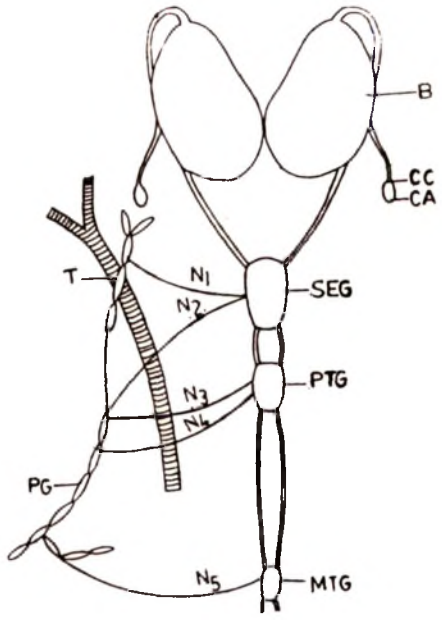

Fig. 1. *Opisina arenosella*: Diagram illustrating endocrine glands.

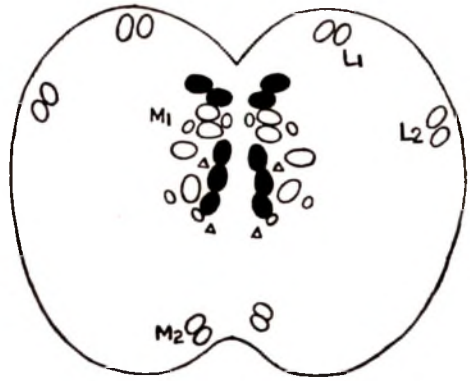

Fig. 2. Diagram illustrating distribution of neurosecretory cells in the brain.

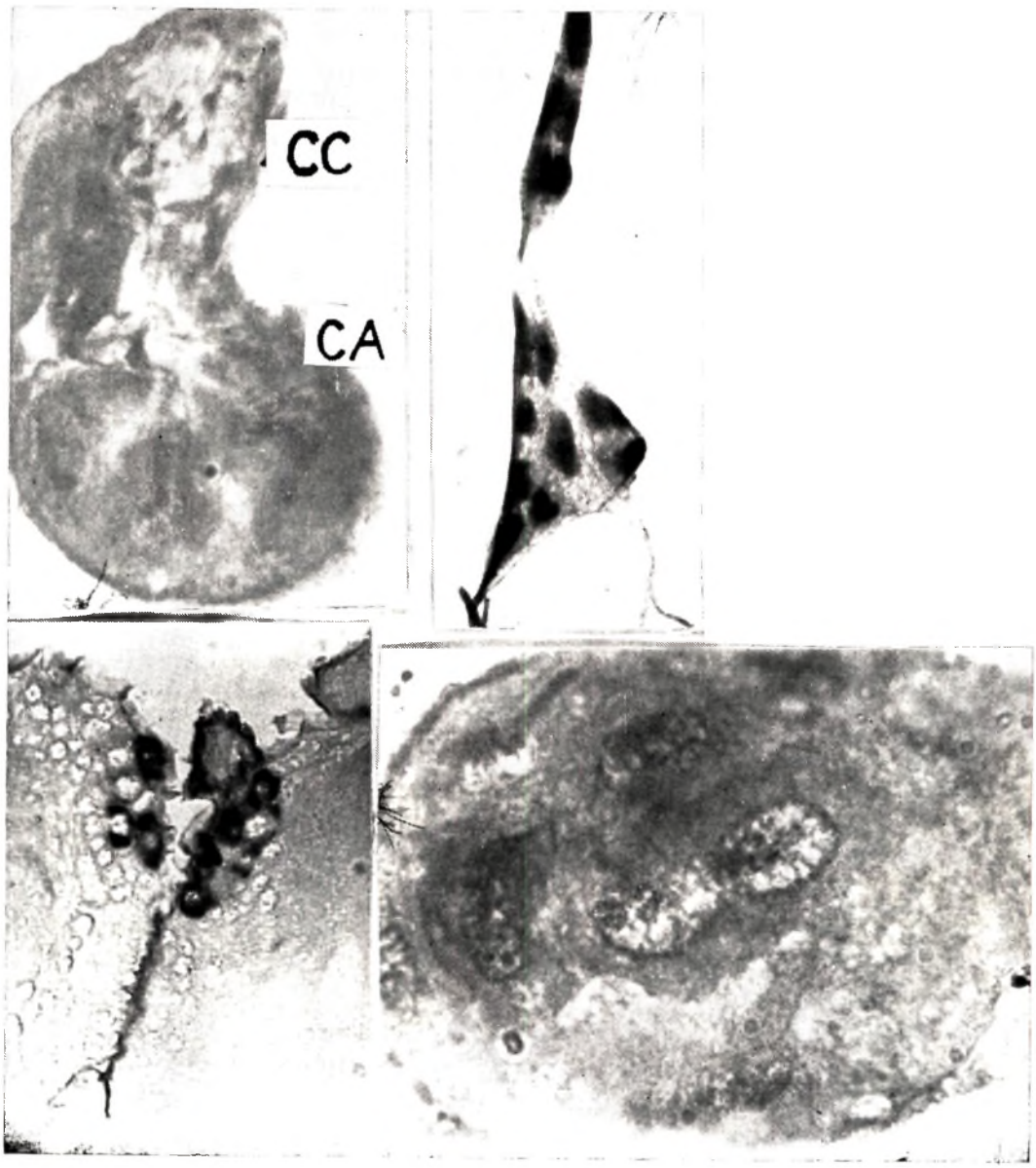

Fig. 3. (photomicrograph, upper left) section of corpus cardiacum-corpus allatum complex, Bouin, Gomori; Fig. 4. (Photomicrograph, upper right) whole mount of prothoracic gland. Bouin, Haematoxylin; Fig. 5. (photomicrograph, lower left) section of the brain showing M_1 group of neurosecretory cells, Bouin, Gomori; Fig. 6. (Photomicrograph, lower right) Corpus allatum, Bouin, Gomori.

ABBREVIATIONS USED

B—Brain; CA—corpus allatum; CC—corpus cardiacum; L_1 and L_2 — Lateral neurosecretory cells; M_1 and M_2 — Median neurosecretory cells; MTG—mesothoracic ganglion; N_1–N_5 — nerves to prothoracic glands; PG—prothoracic gland; PTG—prothoracic ganglion; SEG–suboesophageal ganglion; T–trachea.

stain well with azan. B-cells, 10 μm, are two, stain red with phloxin component of CHP, and blue with azan; C-cells, 15 μm, five in number, stain only with azan, standing out conspicuously in pink colour, scattered among A-cells. Large (20 × 15 μm) and small (12 μm) A-cells are present. M_2 and the two lateral groups L_1 and L_2, consist of 2 A-cells each. In the CC forming the anterior portion of the CC-CA complex (Fig. 3), chromophil and chromosphobe cells are present, with neurosecretory fibre endings. There are also intercellular spaces among the cells. Some neurosecretory fibres also pass through the corpora cardiaca into the corpora allata. The CA (Fig. 6) consists of compactly arranged large and small cells without any intercellular spaces among them. Some neurosecretory fibres enter the CA after passing through the corpus cardiacum.

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BRIEF COMMUNICATION

ENDOCRINE CONTROL OF DEVELOPMENT OF MALE AND FEMALE ACCESSORY SEX ORGANS IN *OPISINA ARENOSELLA* WALKER (LEPIDOPTERA : XYLORYCTINAE)

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Topically applied juvenile hormone analogue S-methoprene did not stimulate growth of the male or the female accessory sex organs, while 20-hydroxyecdysone had a stimulatory effect on the male accessory organs, though not on the female organs, when they were applied to neck- or thorax-ligated larvae or pupae of *Opisina arenosella* Walker.

(*Key words:* endorcrine control, male and female accessory sex organs, *Opisina arenosella* Walker)

The mechanisms controlling development and functioning of the internal accessory sex organs in insects appear to be different in different species. Juvenile hormone (JH) (GILLOT & FRIEDEL, 1976; KOEPPE *et al.*, 1985), ecdysone (SZOPA & HAPP, 1982; SZOPA et al., 1985; KOEPPE et al., 1985) and brain hormone (RANGANATHAN & SRIRAMALU, 1981; BARKER & DAVEY, 1982) have variously been implicated in the control of their development and secretory activity. Our experiments on neck- and thorax-ligated larvae and pupae of *Opisina arenosella* to which the JH analogue S-methoprene or 20-hydroxyecdysone were applied, showed that while JH did not stimulate growth of male or female accessory sex organs, 20-hydroxyecdysone had a stimulatory effect on the male accessory organs though not on the female. Our experiments were conducted: 1) to investigate the probable control by the endocrines of head and thorax, and 2) to study the effect of topically applied JH analogue S-methoprene and 20-hydroxyecdysone on the development of accessory reproductive organ of both sexes in this animal.

Opisina arenosella was maintained in the laboratory as already described (SANTHOSH BABU & PRABHU, 1987). Newly moulted 8th (final) instar larvae were separated into a container and provided with pieces of fresh coconut fronds. The larvae were allowed to feed and grow in the container for three days after which they were transferred to fresh pieces of coconut fronds on which they were allowed to make gallaries. The leaf was changed at four hour interval. The large larvae, still green, which had stopped voracious feeding (stage-I) were separated into containers with fresh coconut leaves, and checked every two hour for larvae turning to pink colour and stop feeding (stage-II), stages III to V were obtained from stage-II (Table 1).

The larvae were anaesthetised using ethyl ether and ligatures were applied either between the head and thorax (neck ligation) or between the prothorax and mesothorax (thorax ligation), with a fine hair loop. Neck ligation removed the influence of the brain, corpora cardiaca and corpora allata on the

accessory sex organs, whereas thorax ligation removed the influence of prothoracic glands also (GIRIJAKUMARI et al., 1990). The larvae, after recovery, were kept in closed petri-dishes. Non-ligated controls were also kept.

S-methoprene (a gift from Dr. G. B. Staal) was dissolved in acetone (1 μg/μl) applied as a single dose either 1μg or 5μg to neck ligated larvae and neck ligated '0' hour pupae. 20-hydroxyecdysone (a gift from Dr. G. Bhaskaran) also dissolved in acetone (1 μg/μl) was applied 3 μg per animal for three consecutive days, on thorax ligated larvae and 1 or 5 μg daily per animal for five days consecutively on thorax ligated '0' hour pupae. Controls were treated with equal volume of acetone only. Substances were topically applied on the ventral side of the abdomen of larva and pupa.

The results (Table 1) showed that pupation could be prevented almost completely, if neck was ligated upto six hours of initiation of wandering. Ligature, 6-10 hours after initiation of wandering resulted in 56% pupation (against 71% pupation in control larvae). The prothoracicotrophic hormone (PTTH) release appears to have started at the end of the first six hours of wandering (stage-II) and continued upto 10 hours (stage-III) and beginning of stage IV. Thorax ligation

TABLE 1. Effect of time of application and position of ligation on pupation in *Opisina arenosella*.

Position of ligature	Stage of larva at ligation	No. of pupae formed, days after ligation									Total no. ligated	% pupating
		1	2	3	4	5	6	7	8	9		
	I	0(0)	0(0)	0(3)	0(1)	0(3)	0(0)	0(0)	0(0)	0(0)	22(10)	Nil (70)
	II	0(0)	0(0)	0(9)	0(3)	0(0)	0(0)	0(0)	0(0)	4(0)	50(13)	8 (92)
Neck	III	0(0)	0(0)	0(0)	2(8)	1(2)	5(0)	4(0)	2(0)	0(0)	25(14)	56(71)
	IV	0(0)	1(0)	3(2)	1(2)	1(0)	0(0)	0(0)	0(0)	0(0)	12 (8)	50(50)
	V	0(0)	0(2)	4(4)	2(2)	2(0)	0(0)	0(0)	0(0)	(00)	10(10)	80(80)
	I–II	0(0)	0(0)	0(0)	0(3)	0(1)	0(0)	0(0)	0(0)	0(0)	22 (5)	Nil (80)
	III	0(0)	0(0)	0(8)	1(2)	2(0)	0(0)	0(0)	0(0)	0(0)	25(15)	12(67)
Thorax	IV	0(0)	2(0)	5(5)	0(7)	3(0)	11(0)	0(0)	0(0)	0(0)	42(15)	50(80)
	V	0(0)	0(3)	0(4)	9(3)	10(0)	9(0)	0(0)	0(0)	0(0)	32(12)	87(83)

Stage I— Last instar larvae more than 3 days of feeding, green coloured, varacious feeding stopped.

Stage II—Green turning pink, feeding completely stopped, wandering initiated (upto 6 hours of initiation of wandering).

Stage III—Active wanderers, pink coloured (between 6–10 h after initiation of wandering).

Stage IV—Begins to settle on covering cloth: some start spinning (between 10–24 hrs after initiation of wandering).

Stage V—Fully spun prepupa.

Control values given in parentheses.

Mortality upto 40%.

inhibited completely pupation in larvae ligatured at stage I and II. In the stage III thorax-ligated larvae, only 12% showed pupation. However in the larvae ligatured at stage IV, 50% of the thorax-ligated larvae pupated as against 80% of puaption in the controls. Hence the release of ecdysone should have started in the active wandering stage larva (stage-III) and continued in stage IV and V. It appears that the prothoracic glands start releasing ecdysone soon after PTTH release, the interval between the two events being very short. This time interval between the two events varies in the different lepidopterans (TRUMAN & RIDDIFORD, 1974). It is also found from our results that the earlier the larvae were ligatured, fewer pupated. Also, ligatured larvae took longer time to pupate.

The pupae resulting from ligation showed certain common characters. They usually showed tanning, but in most cases, the larval skin was not completely cast off; they retained larval thoracic legs. The anterior segments of the abdomen, on the ventral side, remained non-tanned. The wing pads were not formed. These pupae survived for 3-4 days. When dissected on the 3rd day, rudiments of male and female accessory sex organs corresponding to 1-12 day normal pupal development were seen. In the nonpupated ligated larvae, dissected nine days after ligaion the accessory sex organs had not developed at all, while the controls pupated and had fully developed accessory sex organs. From these observations it is clear that, the accessory sex organs need hormones from the anterior part of the body for their development.

Topically applied S-methoprene to ligated larvae had no effect on the time or rate of pupation or on the development of male or female accessory sex organs. It is also seen that while none of the control ligated larvae pupated after 6 days of ligation, 40% of the ecdysone treated ligated larvae pupated between the 9th and 12th days, showing that topically applied 20-hydroxyecdysone penetrated into the body. However, these pupae survived for only 2-3 days.

Development of internal accessory sex organs of both sexes normally starts in the early pupa and becomes fully developed by the mid-pupal stage after which their secretory activity starts. So results of '0' hour neck- and thorax-ligated pupae which were topically applied with S-methoprene or 20-hydroxyecdysone were also noted (Table 2). These pupae lived for 5 to 6 days. In the male, significant development of the accessory sex organs was noticed in the ecdysone treated animals compared to the control, and they were rudimentary in S-methoprene treated individuals and their controls in both sexes. In the female, no significant development of these organs was noticed even after repeated application of ecdysone.

The period of early pupal life in lepidopterans is marked by low or no JH and high ecdysone levels in the haemolymph (TRUMAN & RIDDIFORD, 1974). Therefore it is not surprising that the exogenously applied JH analogue did not stimulate the development of accessory sex organs. Topically applied 20-hydroxyecdysone had different effects with regard to male and female accessory sex organ development. In the male, it stimulated development of the organs when compared to the controls. No significant effect was noticed in females. As topically applied ecdysone had penetrated into the male, it appears that ecdysone alone cannot bring about the complete development of female accessory sex organs. Since exogenously applied JH analogue

TABLE 2. Effect of topically applied S-methoprene and 20-hydroxyecdysone on the development of male and female accessory sex organs of *Opisina arenosella* pupa ligated at '0' hour.

Position of ligation	Treatment (μg/indivdual)		Status of accessory sex organs	
	S-methoprene	20-hydroxy ecdysone	Male	Female
Neck	1		R (R)	R (R)
	5		R (R)	R (R)
Thorax		1 × 5	15.94 ± 2.02* (7.06 ± 1.18)	R (R)
		5 × 5	N. S.	R (R)

* length in mm, significant at 1% level.

R — Rudiments.

Control values given in parentheses.

N. S. Not studied because lower dose was already effective.

alone on neck ligated pupae, or 20-hydroxy-ecdysone on thorax ligated pupae, did not lead to any significant development of female accessory sex organs, it is probable that a factor from the brain is essential for their development.

The development of the male accessory sex glands are found to be ecdysone dependent in *Tenebrio molitor* (SZOPA & HAPP, 1982; SZOPA et al., 1985) and *Plebeiogryllus guttiventris* (RANGANATHAN, 1977). The development and function of female accessory glands have been found to be JH dependent in *Schistocerca gregaria* (SZOPA, 1981), while in *Periplaneta americana* (BODENSTEIN & SPRAGUE, 1959) the growth and differentiation of colleterial glands are under the control of prothoracic glands and secretory activity under the control of corpus allatum. Striking developmental abnormalities have been reported in the female accessory sex organs of hydroprene- and methoprene treated *Scirpophaga incertulas* (CHAKRAVORTY & ROYCHOUDHURI, 1986), showing the dependence of these organs on JH.

The present study shows that in *Opisina arenosella,* the development of male accessory sex organs is ecdysone dependent, while the female accessory sex organs need some factor, perhaps additionally from the brain, for their development.

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BRIEF COMMUNICATION

A NEW WHITEFLY *BEMISIA MULTITUBERCULATA* SP. NOV. (ALEYRODIDEAE: HOMOPTERA) FROM INDIA

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(*Received* 9 *May* 1989)

A species of *Bemisia* collected from *Gmelina* sp. from South India has been found to be new to science and described as *Bemisia multituberculata sp. nov.*

(*Key words* : *Bemisia multituberculata*, *Gmelina* sp., Aleyrodidae)

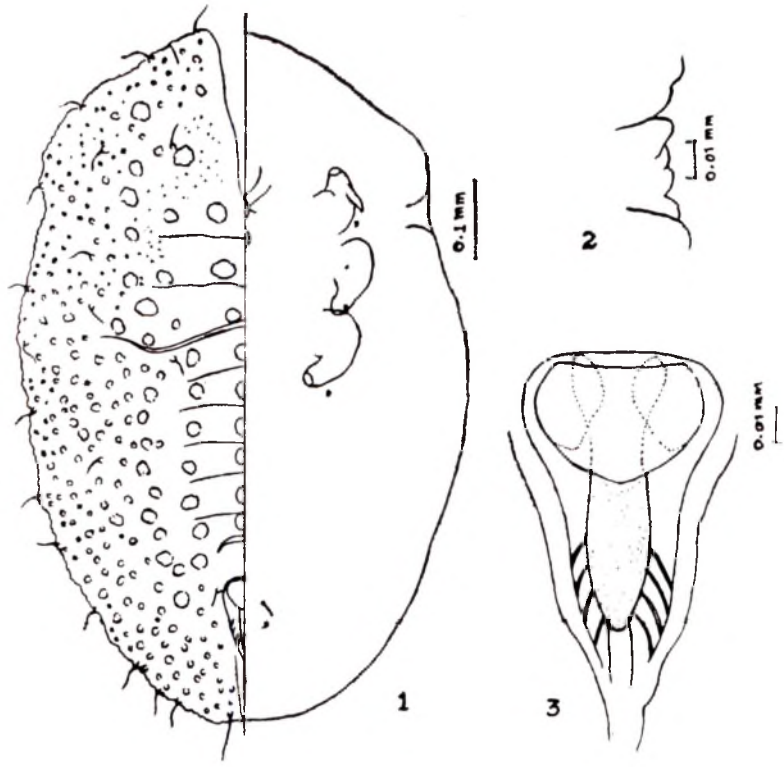
Singh (1931) listed six species of *Bemisia* viz., *Bemisia giffardi* (Kotinsky), *B. lekii* (Peal), *B. grossa* Singh, *B. religiosa* (Peal), *B. achyranthes* Singh and B. *gossypiperda* Misra and Lamba, the last two species were subsequently reported as synonyms of *B. tabaci* (Gennadius) (Mound & Halsey, 1978). *Asterobemisai moringae* David and Subramaniam was also assigned to the genus *Bemisia* by Mound & Halsey (1978). David and Subramaniam (1976) gave details of *B. hancocki* Corbett and *B. tabaci* (Gennadius) and described a new species *B. jasminum* which was subsequently synonymised with *B. giffardi* by Mound & Halsey (1978). Bink-Moenen (1983) synonymised *B. hancocki* with *B. afer* (Priesner & Hosney). With the addition of a new species of *Bemisia graminis* David and Augustine in 1988 the total number of species of *Bemisia* known from India has been arrived at eight; they being *B. afer*, *B. Giffardi*, *B. grossa*, *B. leaki*, *B. moringae*, *B. religiosa* and *B. tabaci*. In this paper a new species, *B. multituberculata* from *Gmelina* sp. is described.

Bemisia multituberculata sp.nov. (Figures 1–3)

Pupal case: White, without wax, elliptical, 0.84 to 0.87 mm long and 0.53 to 0.57 mm wide, found on the under surface of leaves.

Margin: Irregularly crenulate, paired anterior and posterior marginal setae respectively, 30 μm and 37.5 μm long. Caudal and thoracic tracheal pore regions slightly marked; caudal setae arising on tubercles 40 to 45 μm long.

Dorsal surface: Submargin with 12 pairs of setae 25 μm long; a pair of cephalic setae 22.5 μm long, first abdominal setae 15 μm long and eighth abdominal setae 25 μm long. Subdorsum with four pairs of setae, three on cepahalothorax (one pair each laterad of meso- and metathoracic segments and one pair anterior to prothoracic leg) and one pair on abdomen (lateral to the suture separating 3rd and 4th abdominal segments), all the setae arising on distinct tubercles. Dorsum with characteristic rounded tubercle like structures and five distinct rows of enlarged tubercles on abdomen, one row on median area and four rows on submedian area; caphalothorax with six rows of distinct enlarged tubercles on the submedian area. Thoracic tracheal furrows not discernible, caudal tracheal furrow 75 μm long and 7.5 μm wide at the caudal end. Sparsely distributed pores present on the dorsum and submargin. Seventh abdominal segment is much reduced and shorter than sixth and eighth abdominal segments.



Bemisia multituberculata sp. nov.
Fig. 1. Pupal case; Fig. 2. Margin; Fig. 3. Vasiform orifice.

Vasiform orifice: Triangular shaped, 95 to 100 μm long and 60 to 62.5 μm wide with 4 to 5 pairs of lateral teeth. Operculum subcordate; lingula setose, exposed, bears a pair of 22.5 μm long setae sub-apically. Ridges evident on both sides of the vasiform orifice.

Ventral surface: Ventral abdominal setae 32.5 μm long and 35 μm apart. Thoracic and abdominal spiracles visible. Antennae not reaching beyond forelegs. Caudal tracheal fold slightly indicated. Mouthparts visible. A pair of setae at the base of rostrum evident.

Material examined: **Holotype:** 1 pupal case on slide. Vellimalai : *Gmelina* sp. 3. viii. 1987. R. Sundararaj. **Paratypes:** Three paratypes on slides bearing the same details.

This species is close to *Bemisia afer* (Priesner & Hosney) and it differs by the entire dorsum with tubercle like structures of varying sizes, five distinct rows of enlarged tubercles on abdomen and six distinct rows on cephalothorax.

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BRIEF COMMUNICATION

LABORATORY EVALUATION OF COMBINED EFFICACY OF NUCLEAR POLYHEDROSIS VIRUS AND INSECTICIDES AGAINST *HELIOTHIS ARMIGERA* LARVAE

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The combined efficacy of the nuclear polyhedrosis virus (NPV) with very low doses of endosulfan and fenvalerate were tested in the laboratory against second instar larvae of *Heloithis armigera*. A combination of endosulfan 87.5 ppm or fenvalerate 2.5 ppm with NPV at 0.5×10^4 polyhedral occlusion bodies (POB)/ml resulted in a significantly higher percentage of mortality than NPV alone suggesting supplemental synergism. Comparison of LT_{50} values of both the insecticides as well as their combination with virus indicated a temporal synergism.

(*Key words*: laboratory evaluation, combined efficacy, nuclear polyhedrosis virus, endosulfan, fenvalerate, *Heliothis armigera*, second instar larva, supplemental synergism, temporal synergism)

The nuclear polyhedrosis virus (NPV) has been found to be effective against *Heliothis armigera* Hbn. larvae on several crops (JAYARAJ *et al.*, 1985). In some field experiments however, a combination of NPV with reduced doses of endosulfan (RABINDRA & JAYARAJ, 1988) or fenvalerate (SATHIAH, 1987) gave better control of the pest. The results reported in this paper describe the combined efficacy of NPV with very low doses of endosulfan and fenvalerate against *H. armigera* larvae in the laboratory.

The NPV was propagated in fourth instar larvae of *H. armigera* and purified by differential centrifugation. Counts were made with a Neubauer haemocytometer to assess the strength of the polyhedral occlusion bodies (POB). Two concentrations of the virus 0.5×10^3 POB/ml and 0.5×10^4 POB/ml were tested either alone or in combination with fenvalerate (Sumicidin) 2.5 ppm and endosulfan (Thiodan) 87.5 ppm. The treatments were prepared in distilled water containing 0.01% Triton X-100. Chickpea shoots which had been washed previously in distilled water were dipped in the different treatments and shade-dried. The shoot ends were kept in water taken in vials and the bouquet kept inside plastic containers (20 × 15 cm). Second instar larvae of uniform age and size were released on the treated shoots and covered with muslin. The larvae were allowed to feed undisturbed for 24 h after which they were removed to individual vials containing semisynthetic diet lacking formalin. Each treatment had 10–15 larvae and replicated four times. Mortality was recorded at an interval of 6 h starting from the third day. Mortality data were converted into angles and after analysis of variance, means were separated by Duncan's multiple range test. The time-mortality responses were subjected to probit analysis (FINNEY, 1962).

Mortality figures showed that a combination of endosulfan 87.5 ppm and NPV at 0.5×10^3 POB/ml gave significantly a higher mortality level than those produced by either of them alone (Table 1). Addition of fenvalerate 2.5 ppm to NPV also resulted in a

TABLE 1. Combined efficacy of NPV and low doses of pesticides against second instar larvae of *Heliothis armigera*.

	Mean % mortality*	Probit analysis of time-mortality response			
		Chi² @ (n–2)	'b'	LT_{50} (h)	Fiducial limits
NPV 0.5×10^{3} POB/ml	21.5[b]	0.55	4.6	154.9	141.3 — 169.9
NPV 0.5×10^{4} POB/ml	40.7[ab]	1.97	6.3	123.1	115.4 — 131.2
fenvalerate 2.5 ppm	36.7[ab]	0.12	2.3	118.1	97.6 — 143.0
endosulfan 87.5 ppm	28.9[b]	0.16	3.1	137.6	119.5 — 158.3
NPV 0.5×10^{3} POB/ml + fenvalerate 2.5 ppm	58.5[a]	0.76	4.1	84.2	77.0 — 92.2
NPV 0.5×10^{3} POB/ml + endosulfan 87.5 ppm	52.3[a]	1.71	3.8	112.1	101.8 — 123.3

@ All lines are significantly a good fit ($P < 0.05$).

* Means followed by similar letters are not different statistically ($P = 0.5$) by D. M. R. T.

significantly higher percentage mortality than NPV alone. Hence, it may be said that combinations of fenvalerate and endosulfan with NPV resulted in supplemental synergism which is a system of two effective components together producing an effect greater than the algebraic sum of the single effects (BENZ, 1971). KOMOLPITH & RAMAKRISHNA (1978) has also found supplemental synergism when *Spodoptera litura* F. NPV was combined with 5 ppm of DDT or endosulfan. The *Heliothis* NPV has also been reported to be compatible with other insecticides like carbaryl (IGNOFFO & MONTOYA, 1966) and permethrin (LUTTRELL *et al.*, 1979). Further-in field experiments on the control of *H. armigera* on chickpea (RABINDRA & JAYARAJ, 1988), pigeonpea (SITHANANTHAM, 1986) and cotton (DHANDAPANI *et al.*, 1987), a combination of NPV (125–250 LE/ha) with half the recommended dose of endosulfan (0.035% by high volume application) gave significantly better results. Similarly, NPV at 125 LE/ha + fenvalerate at a reduced dose of 0.0025% (high volume) was found to be as good as either of the treatments at full dose (SATHIAH, 1987).

Resistance in *H. armigera* to endosulfan (BASSON *et al.*, 1979) and fenvalerate (GUNNING *et al.*, 1984) has been reported and application of NPV–insecticide mixtures would be a sound approach to insecticide resistance management.

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BRIEF COMMUNICATION

FIELD SCREENING OF SOME PROMISING INSECTICIDES AGAINST *MYTHIMNA SEPARATA* WALKER– A SERIOUS PEST OF RICE CROP

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To evaluate various insecticidal dust formulations and emulsifiable concentrates against the most destructive pest of rice *Mythimna separata* Wlk. field insecticidal trials were conducted during Kharif (rainy) season. The results indicated that 2 percent folidol dust is highly effective in reducing population of the insect and in increasing grain yield.

(*Key words*: Graminae. Noctuidae, insecticidal dust formulations, emulsifiable concentrates, conventional formulations)

In India, larvae of *Mythimna separata* (Noctuidae; Lepidoptera) can feed on a wide variety of plant species belonging to family Graminae (KALODE *et al.*, 1977; GHAI *et al.*, 1979). *M. separata* Wlk, commonly known as ear cutting caterpillar or rice army worm is reported to have assumed the status of major pest of rice crop in Uttar Pradesh. For the last few years the pest was of regular occurrence causing enormous damage to rice crop at its maturity stage. PUROHIT *et al.* (1971) reported endrin 0.2 percent and endosulfan 0.05 percent were effective for control of this pest. BINDRA & SINGH (1973) reported that fenitrothion 0.05 and 0.075 carbaryl and trichlorphos at 0.15 and 0.2 percent gave 100 percent kill. When observed 2 days after spraying, DEOL *et al.* (1981) found monocrotophos 0.3 kg ai per ha, dichlorvos 0.5 kg ai per ha, quinalphos 0.2 kg ai per ha and chlorpyriphos 0.2 kg ai per ha proved very effective for the control of this pest when applied in conventional formulations. The experiments were conducted in the farm area of Rice Research Station, C. S. Azad University of Agriculture and Technology, Kanpur. Promising insecticides were selected for the trials. Each insecticide was replicated three times with one control (no treatment). Randomised Block Design was adopted for conducting the trial having 5 m × 5 m experimental plots with 1 metre border between experimental plots. 25 hills per experimental plot at random were evaluated for pest numbers. 'Saket 4' rice variety was used in the trials. Pre- and post population were recorded 24 hours before and 72 hours after insecticidal treatments. The data on percent mortality and yield were statistically analysed and presented in the table.

The data presented in the table reveal that various insecticides increased the percent mortality of the varying levels. 2 percent folidol (methyl parathion) dust @ 25 kg/ha increased the maximum percent mortality in both the years. During first year, 2 percent folidol dust was statistically at par with 0.1 percent endosulfan EC@ 700 l/ha but it was significantly superior to other treatments. Next to 2 percent folidol dust and 0.1 percent endosulfan EC @ 700 l/ha 5 percent carbaryl dust @25 kg/ha proved best in reducing the

TABLE 1. Screening of some insecticides against *M. separata*.

Treatments	1st year mean % mortality	2nd year mean % mortality	Mean yield	
			1st year	2nd year
10% BHC dust @ 25 kg/ha	56.49	58.76	24.66	15.33
4% endosulfan dust @ 25 kg/ha	84.66	67.02	33.06	16.26
2% Elsan dust @ 25 kg/ha	77.53	67.40	26.93	17.06
5% aldrin dust @ 25 kg/ha	81.65	66.54	28.26	16.26
10% carbaryl dust @ 25 kg/ha	85.77	68.52	39.30	16.46
2% Folidol dust @ 25 kg/ha (methyl parathion)	88.55	89.91	39.63	22.00
0.1% endosulfan EC @ 700 l/ha	86.10	83.85	38.53	20.13
0.5% quinalphos EC @ 700 l/ha	80.36	79.81	31.60	18.40
0.05% phosphamidon EC @ 700 l/ha	79.19	79.11	32.80	18.53
0.05% chlorpyriphos EC @ 700 l/ha	84.27	87.25	29.33	20.66
0.05% fenthion EC @ 700 l/ha	81.83	83.39	27.86	18.93
0.05% isofenphos EC @ 700 l/ha	76.59	76.04	27.60	17.20
Control (No treatment)	0.00	0.00	20.80	10.13
General mean	75.08	69.81	30.79	17.48
Critical difference (CD)	2.71	3.51	0.51	1.19
Coefficient of variation (CV)	2.17	2.99	3.98	5.21

insect population. All insecticidal treatments were signifiacntly superior to control.

During second year, 2 percent folidol dust @25 kg/ha proved best in controlling the pest and was statistically at par with 0.05 percent chlorpyriphos EC @ 700 l/ ha but it was significantly superior to other treatments. Next to folidol and chlorpyriphos EC, 0.1 percent endosulfan EC@ 700 l/ha also proved better in reducing the insect population.

From yield point of view 2 percent folidol dust @25 kg/ha gave maximum yield in both years. 0.1 percent endosulfan EC@ 700 l/ha and 5 percent carbaryl dust and 0.05 percent chlorpyriphos EC@ 700 l/ha, also increased the yield of rice. All treatments were significant among themselves. All insecticidal treatments were significantly superior to control (no treatments).

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BRIEF COMMUNICATION

INFLUENCE OF *LATHYRUS SATIVUS* FLOUR ON THE FEEDING BEHAVIOUR OF *TRIBOLIUM CASTANEUM* (HERBST) LARVAE (COLEOPTERA : TENEBRIONIDAE)

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The response of *Tribolium castaneum* (Herbst) larvae of various ages to the pulse flour, *Lathyrus sativus* was determined through feeding and olfactory tests. *T. castaneum* larvae respond negatively to the pulse flour showing their choice for wholemeal flour in all the experiments.

(*Key words*: *Lathyrus sativus* flour, feeding behaviour, *Tribolium castaneum*)

The rust-red flour beetle, *Tribolium castaneum* (Herbst), originating in India (HOWE, 1952), is a cosmopolitan pest infesting a great variety of stored commodities. The pulse, *Lathyrus sativus* is grown in different parts of the tropical region, and is used in various forms as an important ingredient of the diet.

Now-a-days there is a growing concern over the control of insect pest through nutritional regulations owing to obvious drawbacks in the application of chemical pesticides. From the standpoint of insect pest management, the most promising of the chemical agents functioning interspecifically are in the group which has been referred to collectively as feeding deterrents (DETHIER, 1963, DETHIER et al., 1960) feeding suppressants (BECK, 1965), feeding inhibitors (BENJAMIN & All, 1973), or antifeedants (WRIGHT, 1963; MUNAKATA, 1970). Anti-feedants, being products of living organisms (mostly plants), can legitimately be considered biological control agents (COPPEL & MERTINS, 1977). The present paper determines the influence of *L. sativus* on the feeding behaviour of *T. castaneum* larvae.

The beetles (*T. castaneum*) were originally procured from the Pest Infestation Control Laboratory, Slough, England, and had been cultured on wholemeal flour in the Department of Zoology, Rajshahi University, Bangladesh. A large number of beetles were extracted from the culture and were released on a thin film of wholemeal flour in a Petri dish. Eggs were sieved the next day and were incubated for hatching. Three types of food, viz., wholemeal flour (control), *L. sativus* flour, and a mixture of these flours in equal proportions, were used for feeding tests. One half of the Petri dish (11 cm diameter) was covered with *L. sativus* and the other half served as the control being provided with wolemeal flour. Similar arrangements were made with a *L. sativus* wholemeal flour mixture. Larvae of various ages, reared on wholemeal flour, viz. 1–, 5, 10–, and 15– day old, were released to the centre of the Petri dishes containing food media one cm deep with the aid of a sable hair brush. Three replicates, each with 50 insects, were utilized for each food at each stage of development. The number of larvae on each half of the Petri dish was carefully noted after three hours and were converted into percentages.

[1]To whom correspondence to be made.

Another set of experiments was initiated to find out whether the smell of *L. sativus* flour had any effect on the feeding behaviour of *T. castaneum* larvae. For this one half of a Petri dish was covered with one cm deep *L. sativus* flour and the other half with wholemeal flour of the same depth acting as the control. The Petri dish was covered with a fine-netted cloth and 50, 5-day old larvae, previously raised on wholemeal flour, were placed at the centre of the Petri dish over the cloth. Three similar replicates, each containing 50 larvae, were used. The number of larvae on each side of the Petri dish was carefully recorded and were converted into percentages.

All the experiments were conducted in an incubator set at 30°C and without any light source.

The results are presented in Tables 1 and 2. The data were analysed using a *Chi*-square test for a 50 : 50 distribution of *T. castaneum* larvae from the theoretical expectation. It has been observed that *L. sativus* flour and its mixture with wholemeal flour produced significant deterrencies in *T. castaneum* larvae during feeding, and repelled them. The antifeedant effect of *L. sativus* flour has been observed in *T. confusum* (ALI & KHAN, 1985) and in *T. anaphe* (HASAN & KHAN, 1988). In addition, the detrimental effects of *L. sativus* on flour beetles have been recorded (ALI, 1986; ALI & KHAN, 1986; HASAN & KHAN, 1987).

Potential utilization of feeding deterrents in insect pest suppression programmes has provided the impetus for isolation of these compounds from various plants. A number

TABLE 1. Antifeedant action of *Lathyrus sativus* flour to *Tribolium castaneum* larvae.

Larval age	Food*	No. of larvae in wholemeal flour (out of 150**)	χ^2 – values (1 D. F.***)	Significance
Neonate	a	110	32.67	$P < 0.1\%$
	b	101	18.02	$P < 0.1\%$
5-day	a	114	40.56	$P < 0.1\%$
	b	106	25.62	$P < 0.1\%$
10-day	a	119	51.62	$P < 0.1\%$
	b	97	12.90	$P < 0.1\%$
15-day	a	106	25.62	$P < 0.1\%$
	b	90	6.00	$P < 5.0\%$

* a *L. sativus* flour; b mixture of *L. sativus* + wholemeal flours.
** Three replicates of 50 larvae in each row.
*** Testing null hypothesis that larvae are equally likely to choose wholemeal and a/b.

TABLE 2. Distribution of *Tribolium castaneum* larvae above the half of the Petri dish containing *L. sativus* flour.

Food	Distribution of larvae (out of 150)*	χ^2 — values (1 D. F.)	Significance
a. *L. sativus* flour	45	24.00	$P < 0.1\%$
b. Wholemeal flour	105		

* Three replicates of 50 larvae in each row.

of researchers worked in this line (GILLENWATER & MCDONALD, 1975; MALIM & MUJTABA-NAQVI, 1984; VILLANI & GOULD, 1985). Comprehensive review of antifeedants and their possible role in pest management programmes have been furnished by WRIGHT (1967) and MUNAKATA (1977). The results obtained in the present investigation are indicative of the presence of one or more feeding deterrents which could be profitably used against a number of pests including the present species. These chemical/chemicals need to be extracted through proper analysis. The prospects of preventing insect infestations using natural feeding inhibitors hold promise. However, this method appears to be in its infancy. SCHOONHOVEN (1982) suggests that its further development requires: (1) much more fundamental knowledge about insect behaviour and its chemosensory basis, and (2) the concerted efforts by organic chemists to indentify natural plant substances and to develop procedures for large scale isolation or synthesis of active compounds.

Continuous, heavy usage of hard-core insecticides, e.g., chlorinated hydrocarbons has created a lot of serious problems. One of the most effective alternatives to the chemical method might involve manipulation of natural environmental chemicals, viz., attractants, repellents, stimulants, antifeedants, and arrestants which are generally encountered by insects and act as stimuli, controlling their behaviour.

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BRIEF COMMUNICATION

SOME NEW HOSTS OF LANTANA BUG, *ORTHEZIA INSIGNIS* BROWNE (HEMIPTERA : ORTHEZIIDAE)

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The lantana bug, *Orthezia insignis* Browne was observed on 25 plants belonging to 17 families for the first time. Of the 25 plants, 16 were ornamentals, 5 weeds, 2 medicinal plants, a forest seedling and a spice plant. The infestation on the plants belonging to the family Acanthaceae, Asteraceae, Pertulacaceae and Verbenaceae was most severe and on others, it was slight to moderate.

(*Key words*: *Orthezia insignis*, new hosts)

The lantana bug, *Orthezia insignis* Browne is believed to have been introduced along with its host *Lantana camara* L. from tropical America to British India through Ceylon in 1824 (COOKE, 1908). Though it was found destroying the lantana weed, its use was not encouraged because of its wide host range which included ornamentals, vegetables and plantation crops as far back as 1917. During that time, it was also suggested to destroy the colonies of this bug to prevent its spread to other areas (FLETCHER, 1917).

RAMACHANDRAN & AYYAR (1934) have reported the occurrence of this bug on 30 different hosts from Ceylon and India. Since then the insect has been constantly expanding its host range (CAVALCANTE, 1975; NAIR, 1975; CHACKO *et al.*, 1977; SIDDAPPAJI, *et al.*, 1986; MUNIAPPAN & VIRAKTAMATH, 1986; SRIKANTH *et al.*, 1988 a, b).

During a routine insect collection sortie in the new orchard of the University of Agricultural Sciences, Dharwad, during December 1988, a few ornamentals and weeds were found heavily infested by the lantana bug. A closer observation of the plants in the area revealed many more plants infested by the bug. In all, 25 plants belonging to 17 families were infested by the bug which are new host records (Table 1). Infestation on plants of all ages ranged from slight to heavy. Nymphs and adults were seen on all parts of the plants, viz., leaves, petioles, branches, main stem etc. with maximum colonization on the lower surface of leaves along the midrib. Infestation on roots was also noticed. The severe infestation resulted in development of black sooty mould and drying up of plants from tip downwards, exhibiting a characteristic scorched appearance. Ants attending the attacked plants was also common.

Comparative assessment of severity of infestation revealed that the plants belonging to the families Acanthaceae, Asteraceae, Portulacaceae and Verbenaceae were heavily colonised than others. Infestation on other plants varied from slight to moderate. Of the five species of plants heavily infested, four were ornamentals and remaining one was a weed. Surprisingly lantana, the primary host which was in the close vicinity of the infested plants, was absolutely free from infestation despite being green and healthy. These observations suggested the relative preference of other hosts over lantana.

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TABLE 1. New host plants of *Orthezia insignis* Browne recorded at the University of Agricultural Sciences, Dharwad.

Sl no.	Family	Host species	Economic status of host[a]	Level of infestation[b]
1	2	3	4	5
I	Acanthaceae	*Berlaria cristata*	O	H
		Beloperone guttato	O	Sl
		Jacobinia carnea	O	Sl
II	Apocynaceae	*Catheranthus roseus*	O & M	Md
III	Asteraceae	*Bidens pilosa*	W	Sl
		Callistephus chinensis	O	Sl
		Synedrella nudiflora	W	H
		Tridax procumbens	W	Md
IV	Bignoniaceae	*Bignonia* sp.	O	Md
V	Casarinaceae	*Casuarina equisetifolia*	F	Sl
VI	Commelinaceae	*Tridescantia zabrina*	O	Sl
VII	Crassulaceae	*Sedum* spp.	O	Sl
VIII	Euphorbiaceae	*Acalypha wilkesiana*	O	Sl
		Phyllanthes spp.	W	Md
IX	Lamiaceae	*Oscimum canum*	W	Sl
		O. sanctum	M	Sl
X	Oleaceae	*Jasminum* spp.	O	Sl
XI	Piperaceae	*Peperomia* spp.	O	Sl
XII	Polygoniaceae	*Antigonon leptopus*	O	H
XIII	Portulacaceae	*Portulaca grandiflora*	O	H
		Portulacaria sp.	O	Sl
XIV	Rutaceae	*Murraya koenigii*	Sp	Sl
XV	Urticaceae	*Pilea* spp.	O	Sl
XVI	Verbinaceae	*Clerodendron inerme*	O	H
XVII	Violaceae	*Viola odorata*	O	Sl

[a] F—forest plant, M — medicinal plant, O – ornamental plant.
Sp—spice plant and W – Weed.
[b] Sl—Slight (less than 25 bugs/plant).
Md—Moderate (25 10 bugs/plant).
H—Heavy (More than 50 bugs/plant).

The infestation was localised and was not found in other areas. Possibly the apterous condition of the insect was the cause for slow spread. However, it is only a matter of time for its spread to new areas which are hitherto free from the ravage of this bug. The fact that *Casuarina equisetifolia* which was once free from infestation despite being in the close vicinity of severely infested *Jacoranda mimosaefolia* (SIDDAPPAJI *et al.*, 1986) has also been infested by the bug. It is a clear indication of the possible spread of this bug to new hosts in due course of time. A close watch is being kept on its spread to other plants and attempts will also be made to record the natural enemies and population build up of the bug.

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BRIEF COMMUNICATION

DISTRIBUTIONAL STUDIES OF *MICROTROMBIDIUM SAHARANPURI* DHIMAN AND MITTAL (ACARINA : TROMBICULIDAE : MICROTROMBIDIINAE) IN INDIA

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Microtrombidium saharanpuri, **an ectoparasite of Indian house fly, has been recorded from different parts of India. Detailed distribution of mite is recorded in Uttar Pradesh. Pattern of distribution of mite larvae on host body is also studied.**

(*Key words*: *Microtrombidium saharanpuri*, house fly, India, Uttar Pradesh, geographical distribution)

Microtrombidium saharanpuri has been reported as a new species of trombiculid mite from India (DHIMAN & MITTAL, 1985). This species parasitizes the common Indian house fly, *Musca domestica nebulo* Fabr. (DHIMAN & DHIMAN, 1981). DHIMAN (1983) made some observations on ecological aspects of the aforesaid mite species. Later on, MITTAL & DHIMAN (1989) studied the parasitic behaviour of the mite and its effect on the host fly. MITTAL (1988) made detailed studies on "Bio-ecology and morphology of the mite." No efforts have been made to record its distribution in India. Present study is an endeavour in this aspect.

To record geographical distribution of *Microtrombidium saharanpuri* in India, extensive surveys were carried out in 13 states during 1984 to 1987. These are listed in Table 1. To get an idea of seasonal pattern of distribution, collections were made in 7 Districts of Western Uttar Pradesh, as shown in Table 2. Moreover, distribution pattern of mite larvae on different parts of the host body was studied by examining various body parts of the host under stereoscopic microscope. Material for these studies was taken from the overall collection of mite infested host flies throughout India.

Distribution of M. saharanpuri *in India:*

The study has shown the presence of *M. saharanpuri* in all except two states of India where collections were carried out (Table 1). It was found in Jammu and Kashmir and Assam. The latter state was surveyed during November and December while the former during summer as well as winter months. Cold climatic conditions is the likely reason for its absence from these states. Among the states of India which were surveyed, maximum percentage of infested flies was recorded from Uttar Pradesh and Bihar and minimum from Rajasthan and Gujarat. Low percentage in the latter two states may be attributed to dry climate.

Distribution of M. saharanpuri *in western districts of Uttar Pradesh:*

Four years' data on the collection of *M. saharanpuri* in 7 western districts of Uttar

TABLE 1. Distributional study of *Microtrombidium saharanpuri* in India.

Sl no.	States	Percentage of infested flies during			
		1984	1985	1986	1987
1.	Rajasthan	8	7	6	10
2.	Maharashtra	18	30	26	22
3.	Gujarat	6	8	9	7
4.	Andhra Pradesh	10	21	22	16
5.	Madhya Pradesh	20	24	22	28
6.	Karnataka	30	18	16	21
7.	Bihar	30	32	38	34
8.	Haryana	28	30	32	26
9.	Punjab	18	22	30	24
10.	West Bengal	24	26	30	22
11.	Uttar Pradesh	38	36	31	40
12.	Jammu and Kashmir	—	—	—	—
13.	Assam	—	—	—	—

Pradesh carried out during summer (July) and winter (December) is presented in Table 2. The mite was seen widely distributed throughout this region, except in the hilly district of Dehra Dun, where it was absent in two towns, viz., Mussoorie and Chakrata, which are located at higher elevations and therefore, have a relatively cold climate. Its occurrence in the two other towns of Dehra Dun District, viz., Dehra Dun and Rishikesh was not markedly different from the remaining areas of the region where survey was carried out. Another interesting observation was the markedly higher rate of parasitization during the summer month of July, which is considered the peak season of parasitization. The only exception was in Dehra Dun during 1987, where the incidence was slightly higher during the winter. The percentage of parasitization in the six remaining districts surveyed was distinctly higher during July, ranging between 20% to 40%, as compared to December, when it ranged between 2% and 25%.

Distribution of mite larvae on host body:

The mite larvae were found attached on the proboscis, occipital region, thorax, abdomen, wings and legs (Fig. 1). Table 3 indicates that preferable sites were wing axillaries, cervical membrane and abdominal joints (pleural membrane and connexival membrane). The largest number of larvae were collected on abdomen and the least number on the legs. It appears that the larvae prefer to attack the softer area of the integument which provide least resistance for piercing and sucking the host body fluids.

It is envisaged to take up further studies to map the country-wide distribution of this important ectoparasite of house fly in India.

TABLE 2. Distributional study of *Microtrombidium saharanpuri* in western districts of Uttar Pradesh.

Sl no.	Year	Dehra Dun			Sanaranpur			Muzaffarnagar			Meerut			Moradabad			Bulandshahr			Bijnor		
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1.	1984 July	150	50	33.3	200	80	40	200	68	34	100	36	36	100	30	30	150	50	33	100	32	32
	1984 December	50	10	5	50	5	25	50	15	7.5	50	12	6	50	11	5.5	50	16	8	50	8	4
2.	1985 July	150	45	30	200	75	37.5	200	55	27.5	100	33	33	100	39	38	150	55	36.6	100	30	30
	1985 December	50	12	6	50	15	7.5	50	17	8.5	50	16	8	50	10	5	50	8	4	50	7	3.5
3.	1986 July	150	50	33.3	200	68	34	200	65	32.5	100	35	35	100	32	32	150	52	34.6	100	25	25
	1986 December	50	10	5	50	14	7	50	12	6	50	9	4.5	50	11	5.5	50	8	4	50	4	2
4.	1987 July	150	50	33.3	200	80	40	200	58	29	100	39	39	100	38	38	150	55	36.6	100	20	20
	1987 December	50	9	45	50	13	6.5	50	18	9	50	10	5	50	12	6	50	10	5	50	15	7.5

A = Number of catches. B = Number of infested flies. C = Infestation percentage.

TABLE 3. Distribution of mite larvae on the host body *Musca domestica nebulo* Fabr. in the month of July.

Sl. no.	Fly no.	Number of mite larvae on different body parts													Total No. of mites
		Head		Thorax				Abdomen			Wing	Legs			
		Pro-boscis	Occipital region	Neck	Pro-thoax	Meso-thorax	Meta-thorax	Dorsal	Ventral	Laterai	Axi-llaries	I	II	III	
1.	I	X	2	1	2	X	3	5	2	4	4	1	1	2	27
2.	II	1	3	2	X	1	X	4	3	6	3	2	0	1	26
3.	III	X	X	X	2	1	1	6	2	X	X	X	X	X	12
4.	IV	2	X	X	X	3	X	2	3	1	4	2	0	0	17
5.	V	X	X	X	X	X	4	X	X	3	2	X	X	X	9
6.	VI	3	4	5	X	2	2	6	2	2	3	2	2	0	40
7.	VII	X	X	X	X	X	X	1	1	X	X	X	X	X	2
8.	VIII	X	3	1	X	1	1	2	2	1	2	1	1	1	16
9.	IX	1	2	X	X	2	1	2	2	1	2	1	2	1	17
10.	X	X	X	2	X	3	X	X	X	X	2	X	X	X	7

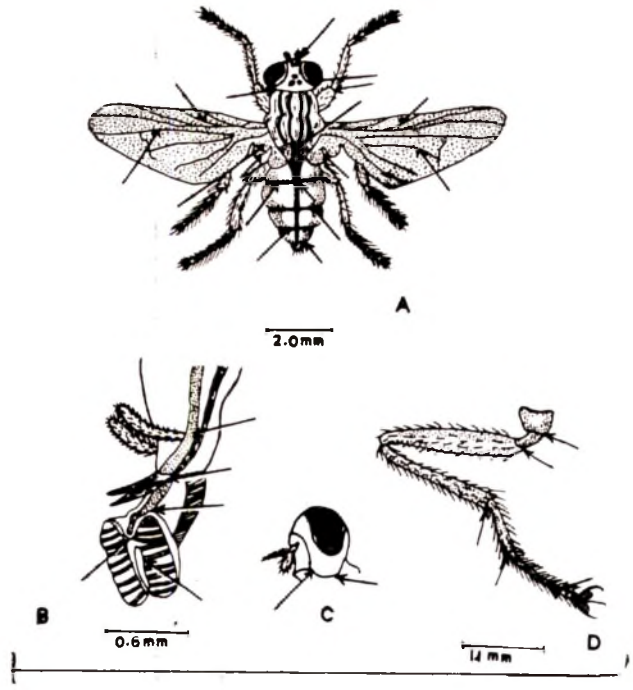

Fig. 1: Attachment site of *M. saharanpuri* on the host, *Musca domestica nebulo* (indicated by arrow).
A. on host body. B. on mouth parts. C. on head region. D. on leg.

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BRIEF COMMUNICATION

RECORDS OF SOME NEW HYMENOPTERAN PARASITES OF *CHROMATOMYIA HORTICOLA* (GOUR.) (DIPTERA : AGROMYZIDAE) FROM AGRA

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(*Received* 10 *March* 1989)

Two braconid and two pteromalid parasites were recorded first time from India on *Chromatomyia horticola*.

(*Key words*: *Chromatomyia horticola*, parasite)

The pea leaf miner, *Chromatomyia horticola* (Gour.) (Diptera : Agromyzidae) is a serious pest of agriculturally important crops like *Pisum sativum* L. (Hindi: Matar) and *Brassica compestris* L. (Hindi : Sarson) in addition to a large number of ornamental plants, vegetables and fodder crops. A total of eleven hymenopteran parasites viz., *Opius turcicus* Fischer, *O. exiguus* Wesmael, *O. phaseoli* Fischer, *Bracon* sp. (Braconidae); *Diglyphus isaea* (Walker), *Chrysonotomyia formosa* (Westwood), (*Chrysonotomya thakeri* Subba Rao, *Pediobius acantha* (Walker), *Eulophus* sp. (Eulophidae) and *Sphegigaster brunicornis* (Ferriere), *S. stepicola* Boucek (Pteromalidae) has been recorded by Singh and Kumar (1985) on *C. horticola* from different parts of India. Kumar (1984, 1985) has reported that these parasites are effective in pest population regulation. Earlier workers like Ahmad and Gupta (1941), Kaurva *et al.* (1969), Mani (1971) Gokulpure (1972) and Singh (1982) have also reported few parasites on *C. haorticola* from India. The present paper deals with the new records of parasites reared on *C. horticola*.

The material for the present study was collected from the cultivated fields of *P. sativum* and *B. campestris* around Agra. The parasites were collected in the laboratory from the field collected pupae of *C. horticola* reared at 27 ± 2°C room temperature and 70 ± 5% relative humidity.

The names of new parasites are given below:

Family — Braconidae : *Apanteles* sp., ex. *C. horticola* on *P. sativum*, 1980.

Family — Eulophidae : *Diglyphus* sp. ex. *C. horticola* on *P. sativum* and *B. campestris*, 1980.

Family — Peteromalidae : *Sphegigaster* sp., ex. *C. horticola* on *P. sativum* and *B. campestris*, 1981; *Callitula* sp. ex. *C. horticola* on *P. sativum* 1982.

On the basis of the emergence from pupae these parasites are categorised as pupal parasites. *Diglyphus* sp. and *Sphegigaster* sp. constitute the dominant component of the parasite complex and parasitize 20.00 — 25.00 percent and 10.00 — 12.00 percent pest population respectively. *Apanteles* sp. and

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Callitula sp. are of minor significance as the parasitization caused by them is almost negligible.

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BRIEF COMMUNICATION

FIELD EVALUATION OF INSECTICIDES FOR THE CONTROL OF LEAF GALL THRIPS (*LIOTHRIPS KARNYI* BAGNALL) ON BLACK PEPPER[1]

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(*Received* 10 *March* 1989)

Field evaluation of six insecticides at Wynad (Kerala) for the control of leaf gall thrips (*Liothrips karnyi* Bagnall) on black pepper (*Piper nigrum* L.) indicated that sprays of 0.05 percent monocrotophos and dimethoate were effective in controlling the pest infestation when applied as the new flushes emerge.

(*Key words* : black pepper, *Piper nigrum* L., leaf gall thrips, *Liothrips karnyi* Bagnall, insecticidal control)

Leaf gall thrips (*Liothrips karnyi* Bangall) (Thysanoptera: Phlaeothripidae) is an important pest of black pepper (*Piper nigrum* L.) in Kerala especially at higher altitudes and also in nurseries. The feeding activity of the pest induces the formation of marginal leaf galls and also causes reduction in size, crinkling and malformation of the infested leaves. In a preliminary trial, monocrotophos 0.02 percent was the most effective against the pest followed by dimethoate 0.03 percent (NAIR & CHRISTUDAS, 1976). Fenvalerate and methamidophos (2 g ai per vine) were also reported to be effective against the pest (VIVEKANANDAN *et al.*, 1981). Trials were undertaken to evaluate the efficacy of six insecticides for the control of the leaf gall thrips at Wynad (Kerala) where the infestation of the pest was usually high (DEVASAHAYAM, unpublished) and the results are reported here.

The trials were laid out at Kuppadi (Wynad District, Kerala) in a six year old black pepper plantation (cv. 'Karimunda'). The insecticides chosen included endosulfan, quinalphos, dimethoate, monocrotophos and phosphamidon each at a concentration of 0.05 percent and malathion at 0.1 percent. These were selected based on studies on their residual toxicity conducted under green house conditions and reported earlier (DEVASAHAYAM, 1989). A Randomised Block Design was adopted with a plot size of three vines per treatment each replicated three times. The insecticides were sprayed with a rocker sprayer to run off level during July coinciding with the emergence of new flushes. An untreated control was also maintained without spray. The percentage of leaves infested by the pest under various treatments was determined 15 and 30 days after treatment. The trials were conducted for three years consecutively and the data were subjected to pooled analysis.

The relative efficacy of the six insecticides evaluated against leaf gall thrips is presented in Table 1. The percentage of infested leaves was significantly less in all the treatments as compared to untreated control both at 15 and 30 days after treatment. At the end of 15 days after treatment dimethoate was significantly superior to phosphamidon, malathion and quinalphos and was on par with monocrotophos and endosulfan. Plots treated with dimethoate had the lowest percentage of infested leaves (3.2) followed by

TABLE 1. Effect of insecticides on the control of leaf gall thrips on black pepper (combined analysis of three years data).

Insecticide and dosage (percent ai)	Mean percentage of infested leaves			
	15 dat		30 dat	
endosulfan 0.05	5.6	(13.68)	20.6	(27.01)
malathion 0.1	9.4	(17.91)	21.1	(27.35)
quinalphos 0.05	9.9	(18.37)	22.7	(28.48)
dimethoate 0.05	3.2	(10.38)	16.8	(24.20)
monocrotophos 0.05	4.1	(11.66)	12.0	(20.27)
phosphamidon 0.05	9.3	(17.73)	21.3	(27.52)
Control	24.2	(29.50)	26.4	(30.95)
CD at 5% level	4.02		2.22	

Figures in parentheses are transformed values. dat = days after treatment.

those treated with monocrotophos (4.1). At the end of 30 days after treatment nonocrotophos was significantly superior to all the treatments. Plots treated with monocrotophos had the lowest percentage of infested leaves (12.0) followed by those treated with dimethoate (16.8).

The results of the trials indicated that spraying of monocrotophos or dimethoate at 0.05% percent could be recommended for the control of leaf gall thrips on black pepper. The first spray is to be given during June/July coinciding with the emergence of new flushes. A second spray may be given after 25–30 days in case the infestation persists. Since the flushing period in grown up vines is generally restricted to June-July in Kerala, two sprays during this period would be adequate.

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The author is thankful to Sri JOSE ABRAHAM for statistical analysis of the data and also to the Wildlife Warden, Wynad Wildlife Sanctuary for permitting him to undertake the trials in their plantation.

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REPORT AND NEW RECORDS

ON THE OCCURRENCE OF THE WHITEFLY *ALEUORDICUS MACHILI* TAKAHASHI (ALEURODICINAE, ALEYRODIDAE, HOMOPTERA) IN INDIA

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(*Received* 19 *September* 1989)

The whitefly *Aleurodicus philomenae* David, belonging to the subfamily Aleurodicinae, collected earlier from Maharashtra, has been synonymised with *A. machili* Takahashi. It has also been found on a new host *Litsea travancorica* Gamble in Kerala State.

(*Key words*: *Aleurodicus philomenae*, *Aleurodicus machili*, Aleurodicinae, whitefly)

David (1987) reported for the first time the occurrence of a whitefly belonging to the subfamily Aleurodicinae in India, and described the species collected from a shrub *Persea macrantha* (Nees) Kosterm (Lauraceae) in Mahableshawar (Maharashtra State) as a new species under the name *Aleurodicus philomenae*. Dr. (Miss) Louise M. Russell of the United States Department of Agriculture after examining the paratype and the description of the above species pointed out that "This species is very similar to *A. machili* Takashshi, also described from a plant belonging to the Lauraceae." Based on detailed re-examination of the specimens it was concluded that *A. philomenae* David is a new synonym of *A. machili*, a whitefly species described by Takahashi (1931) from Formosa, the host being *Machilus* sp.

Interestingly the same species was collected by the second author (SS) on 1st Apil 1989 in Pittady (Kerala State) from a new host *Litsea travancorica* Gamble, a plant belonging to the family Lauraceae.

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The first author (BVD) is grateful to Dr. (Miss) Louise M. Russell, Research Entomologist, ARS, USDA, Beltsville Agricultural Research Centre, Beltsville, Maryland 20705, for her critical comments and helpful suggestions.

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OBITUARY

M. G. RAMDAS MENON

1.1.1913 to 28.2.1990

MANNOORE GOPALA RAMDAS MENON passed away on 28.2.1990 after a period of brief illness culminating in cardiac failure at Trichur (Kerala). He was an astute, devoted entomologist who made substantial contributions to insect taxonomy and systematics.

Dr. Menon carried out his early education in different schools in and around Trippunithura (Ernakulam Dist.) and Trichur due to the frequent transfers of his father, the late Shri. Gopala Menon, a school teacher. As a boy, Menon's interest in Natural History was kindled by the rich and diverse insect life in the lush vegetation of his village. He used to make excellent sketches of animals and plants around him. In fact, he even went for a course in painting and drawing after completing SSLC in 1929.

He completed his Intermediate from the Maharaja's College, Ernakulam, in 1932 and joined Wilson College, Bombay for his B.Sc in Botany. Upon graduation he started working for his M.Sc. (in Zoology). The

topic of research was a revision of Indian Psocoptera, a group which was very poorly known at that time. After evaluation of the first year's work and the progress attained, he got special permission to submit his work directly for Ph.D. He deserves the credit for being the first to be awarded doctorate in Zoology from Bombay University.

After taking his Ph.D. in 1940, Dr. Menon had a chequered career in several institutions of repute: Lecturer in Wilson College and Khalsa College; Assistant to the Imperial Entomologist in IARI, Delhi; Entomologist in the Directorate of Plant Protection and Quarantine, Madras and Senior Systematic Entomologist in IARI culminating in the Emeritus Scientistship of the ICAR (1975-1978). Thereafter he served as the Consultant Insect Taxonomist in the College of Horticulture, Kerala Agricultural University, Vellanikkara.

Prof. Menon had varied interests in entomological research which ranged from insect biology, ecology, morphology, taxonomy, chemical control and so on, although his major contribution was to insect taxonomy. After his pioneer work on the Indian Psocoptera, he covered a variety of insect groups such as Aphididae, Membracidae, Tingidae, Cicadellidae, Fulgoridae, Coreidae, Miridae, Coccidae, Pentatomidae, Lygaeidae (Hemipteroidea); Chalcidoidae, Pteromalidae, (Hymenoptera); Noctuidae, Pyralidae (Lepidoptera), Syrphidae (Diptera) as well as Eriophyidae and Phytoseidae (Acarina). Under each of these groups a varying number of so-far undescribed species have been brought to light. In recognition of his contributions, several new species have been named after him by workers from India and abroad. He had published over 80 research papers in Indian as well as foreign journals.

Dr. Menon's contribution to taxonomy cannot be measured solely by his published work. He shared his knowledge generously with his colleagues and students. He would try to find solutions to problems submitted to him even by keeping aside his own work, although this attitude had at times resulted in setbacks in the timely completion of his own research programmes. He never wanted to publish papers unless it contained solid and strongly convincing results. It is a pity that the several volumes of his check-list on Indian Insects still remain unpublished due to this reason.

Dr. Menon was a unique personality with many facets. Though basically a zoologist he nurtured varied interests in other unrelated fields like embroidery, stitching, mat making, sculpture, cookery etc. In fact he secured a first prize in the embroidery work competition held by the staff club, IARI. He used to derive considerable pleasure by serving cookies and biscuits baked by him to his students and friends.

He had worked in the British Museum (Natural History) London, U.S. National Museum, Washington as well as at the Natural History Museums in Switzerland, Italy and France. He had mastery in several languages especially Latin, German and French.

Dr. Menon was an active member in several professional organizations : Fellow of the Entomological Society of India; Fellow of the Royal Entomological Society of London; Member, Society of Systematic Zoology, Washington and Member, Association for the Study of Oriental Insects. He was on the Editorial Board of a number of journals– *Indian Journal of Entomology*, *Oriental Insects*, *Journal of Animal Morphology and Physiology* as well as the *Indian Zoologist*, for varying periods. He also served as an examiner for M.Sc. and Ph.D. programmes of a number of Universities and had guided

the research work of several students (M.Sc–7; Assoc. IARI–7; Ph.D–11).

Dr. Menon was a quiet and unassuming man but his intellectual superiority was obvious to those who worked with him. The depth of his knowledge was astounding. Above all, he was a keen and intelligent observer of nature with a deep knowledge of many fields.

He is survived by his wife, two daughters and a son. His wife's interest in his work and the strong support she gave throughout their happy married life contributed substantially to Dr. Menon's success in the scientific pursuits. A few days before his demise, Prof. Menon gave me a book 'The Silent Watch-maker' by Richard Dawkins in which the author identifies those aspects of evolution that people find hard to believe and removes the barriers to credibility one by one. In the fag end of his life Dr. Menon was devoting considerable attention to philosophical thoughts on vitally important topics. Prof. Menon's life and work will remain to inspire others and he will be remembered with affection by all those who knew him.

GEORGE MATHEW

BOOK REVIEW

INSECT AND ENVIRONMENT — III : NUTRITIONAL ECOLOGY OF INSECTS AND ENVIRONMENT — Proceedings of the Symposium held at Muzaffarnagar, October 2–4, 1988. Edited and Published by S. C. GOEL, Muzaffarnagar, hard-bound, 1989, 331 pp., Rs. 200/-.

This book comprises the proceedings of the third of a series of symposia entitled "Insects and environment" held in Sanatan Dharm College, Muzaffarnagar, during 2–4 October 1988, and has been compiled, edited and published by Dr. S.C. Goel, P.G. Department of Zoology, Sanatan Dharm College, Muzaffarnagar 251001, India. The volume comprises 42 papers presented by scientists from all over India at the symposium. Most of the papers deal with insects of economic importance. A wide variety of topics like ecological energetics; food consumption and utilization; developmental biology; nutritional effects; dietary preference; behaviour; digestive enzymes; environmental effects; influence of heavy metal ions, insecticides, hormones, exotocins and plant alkaloids, are covered in the papers. The editor has made commendable work; most of the papers are detailed with relevant data presented in tables; the book, available from Dr. S. C. Goel, will be undoubtedly quite useful to research workers in the above fields, and priced at Rs. 200/-, is quite affordable to libraries.

V. K. K. PRABHU

CONCEPTS OF INSECT CONTROL by M. R. GHOSH. Wiley Eastern Limited, New Delhi, 1989, 274 pp., Rs. 80/-

The book, as the name indicates, deals with various concepts or principles of insect control and is made up of nineteen chapters: problems appreciation; understanding pests; injuries and damages by pests; forecasting pest outbreaks; decision making in pest control; control stratagies; mechanical and physical control; cultural control; plant resistance to insect attack; biological control; chemical control; legal control; fumigants and storage grains; insecticides and safety measures; sterility methods; attractants, repellants and antifeedants; nutritional control; control by hormonal imbalance; and integrated control. The book also includes References of eight pages and Index of six pages. In spite of already pruning quite a lot of details on insecticide application equipments, as acknowledged by the author under preface, there is still too much remaining, especially the given figures, which are not quite relevant for a book of this kind. The book, however, will be of considerable use to students and teachers of Entomology, and at Rs. 80/-, is quite affordable, and could be recommended.

V. K. K. PRABHU

INFORMATION TO CONTRIBUTORS

Scope: *ENTOMON* will accept original articles (but not reviews) arising from studies on insects, arachnids, and myriapods. Articles of not direct relevance to entomologists, like those on assessment of damage caused by insects, plant breeding againt insect resistance and those on insecticide residue analysis etc., will not be considered. Papers purely of morphological, histological or anatomical nature based on light microscopy will not be considered though those on systematics are acceptable.

General: Manuscripts submitted for publication in the journal should not have been published or submitted for publication elsewhere. Manuscript in *duplicate in all respects including figures*, must be sent by *Registered mail* to the *Managing Editor*, *ENTOMON*, *Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India* 695 581. *Authors need not necessarily be members of the Association for Advancement of Entomology.*

Articles should be in English only and may be either *Brief Communications* not exceeding two printed pages, or *Papers* normally not exceeding ten printed pages. *Reports* and *New Records* not exceeding a column, as well as biographical notes, *Announcements* of Seminars/Symposia and other items of entomological interest etc., will also be accepted for publication. Books for Review may also be sent to the Managing Editor.

While preparing the manuscript, the authors should consult a recent issue of the journal and follow its style closely.

Articles should be neatly typed in *double space*, including *References, Legend, Tables, Abstract* and *Foot notes*. This is essential to facilitate editorial work. Single spacing should be completely avoided. Never underline, *unless* italics is intended (eg. generic and spacific names; name of journals etc.). Type only on one side of good quality *bond paper*, leaving sufficient margin.

Tables should be given on sheets separate from the text.

Illustrations, when desirable, should accompany the script separately. References to the illustrations provided should invariably be made in the text at relevant places, and they should be always accompanied by legend, typed on separate sheets and not along with figures. Line drawings (orginal India ink drawings; one of the copies may however be a good photocopy) and photographs (no photocopies) should be consecutively *numbered* together *serially* in Arabic numerals without distinction between drawings and photographs (ie., as Figs. 1, 2, 3, 4 etc., and *not* as: Figs. 1a, 1b, 2a, 2b or a, b, c, d. etc). Photographs should as far as possible be organised and mounted in the form of plates. Blocks upto an equivalent of one full page size are allowed free of cost. However, additional blocks will be fully charged for. Authors are advised to keep the illustrations to the minimum and carefully plan their illustrations so as to occupy minimum space and permit sufficient reduction. Too small lettering in the figures should be avoided. Strict adherence to the above instructions ill facilitate early publication of accepted article.

Reprint: 50 *reprints will be supplied gratis.* Additional reprints required may be purchased. Order for additional reprints will have to be placed as soon as the paper is accepted for publication in the journal. Table showing the cost of reprints will be supplied to authors when acceptance of the article is communicated.

ANNOUNCEMENT

National Symposium: INSECT & ENVIRONMENT – IV

IV National Symposium entitled "Insect & Environment–IV" on Growth, Development and Control Technology of Insect Pests, is being organized by Dr. S. C. Goel, who will be the Director of the Symposium, at P. G. Department of Zoology, Sanatan Dharm College, Muzaffarnagar 251001, from October 2–4, 1991. The Symposium is expected to cover various aspects of Reproductive behaviour and environmental impact; Cellular differentiation and biochemical impact; and Control strategies and biotechnology, of insects. Last Date for receipt of 200–word abstracts, is 31st July 1990. Further details can be had from the Director, at his above address.

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